MISSION ANALYSIS PROGRAM FOR SOLAR ELECTRIC PROPULSION (MAPSEP)

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VOLUME II - USER'S MANUAL

Prepared by:

G.L. Shults
R.J. Boain
K.R. Huling
T. Wilson
P.E. Hong

Planetary Systems Mission Analysis and Operations Section
Denver Division
Martin Marietta Corporation

For

National Aeronautics and Space Administration
Marshall Space Flight Center
Huntsville, Alabama

FOREWORD

MAPSEP (Mission Anslysis Program for Solar Electric Propulsion) is a computer program developed by Martin Marietta Aerospace, Denver Division, for the NASA Marshall Space Flight Center under Contract NAS8-29666. MAPSEP contains the basic modes: TOPSEP (trajectory generation), GODSEP (linear error analysis) and SIMSEP (simulation). These modes and their various options give the user sufficient flexibility to analyze any low thrust mission with respect to trajectory performance, guidance and navigation, and to provide meaningful system related requirements for the purpose of vehicle design.

This volume is the second of three and contains the input/output description of MAPSEP and other user related information. Other volumes relate to analytical program descriptions and to program logical flow.

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1. INTRODUCTION

This manual provides the user of MAPSEP (Mission Analysis Program for Solar Electric Propulsion) with all the information necessary to input the program and to obtain meaningful output. In addition to listing all the input variables, their definitions, units, etc., there are chapters discussing recommended usage and limitations, and sample runs.

MAPSEP is composed of three primary modes, each of which performs a given function in a trajectory analysis. TOPSEP (Targeting and Optimization for SEP) evaluates performance by generating realistic integrated trajectories which meet whatever mission and system constraints are imposed by the user. GODSEP (Guidance and Orbit Determination for SEP) evaluates trajectory dispersions, using linear error analysis techniques, in the presence of dynamic and navigation uncertainties. SIMSEP (Simulation for SEP) deterministically simulates single or multiple trajectories in the presence of discrete system errors.

For the user who is unfamiliar with MAPSEP, it is recommended that he first study, briefly, Chapters 2 and 3 on Input and Output, respectively, to familiarize himself with some of the nomenclature and options. Next, a careful study of Chapter 4 on Operating Guidelines will yield considerable insight on MAPSEP Usage. The user can then return to Chapters 2 and 3 for specific information on his particular application. Finally, as additional background information, it is recommended that the Analytic Manual (Reference 1) and Program Manual (Reference 2) be referred to extensively.

2.0 INPUT

The basic input to MAPSEP is in the form of namelist data, fixed field cards and magnetic tape. This chapter describes all available input. Chapter 4 will discuss the organization of this input for specific analysis functions.

All MAPSEP modes require the namelist $TRAJ which contains reference trajectory and spacecraft characteristics. If desired, this namelist can be written on a disc file (STM) and eventually stored on magnetic tape to facilitate later runs or stacked cases in the same run. Following $TRAJ is mode peculiar input.

The reference trajectory generation mode (TOPSEP) requires the namelist $TØPSEP to follow $TRAJ. $TØPSEP contains parameters that determine the strategy for generating a trajectory which meets desired target conditions and mission constraints. The reference trajectory defined in $TRAJ is used as the initial guess.

The linear error analysis mode (GODSEP) requires the namelist $GØDSEP immediately after $TRAJ. $GØDSEP contains system uncertainties and navigation and guidance related data to perform a covariance analysis about the reference trajectory. Following $GØDSEP, fixed field cards are input to describe measurement and propagation schedules. Two disc files or tapes are often used: STM and GAIN. These files contain trajectory and transition matrix data (STM) and a-priori covariances and orbit determination filter gains (GAIN) to improve computational speed and to provide additional flexibility. Another namelist $GEVENT is optional and contains guidance event information.

The trajectory simulation mode (SIMSEP) requires the namelist $SIMSEP to follow $TRAJ. $SIMSEP contains parameters which describe the scope of the simulation, expected dynamic errors, and cumulative statistics from previous SIMSEP runs. Following $SIMSEP are a set of $GUID namelists, one for each guidance correction maneuver. $GUID describes the strategy, knowledge or estimation uncertainties and cumulative statistics for that particular maneuver.

The trajectory display node (REFSEP) requires only the namelist STRAJ followed by scheduling cards, similar to those used in GODSEP. The fixed field schedule cards define: types of data displayed, span of interest, and frequency of printout.

For those users who can vary the amount of blank common storage in their runs, a guideline to estimate the total MAPSEP core requirements is given below. Blank common length is related directly to the dimension of the dynamic state (NDIM) used in transition matrix (STM) computation, and, the total augmented (knowledge) state (NAUG). The values of "program" and "blank common" must be added to compute the total decimal core for a CDC 6500. Other operating systems must scale these requirements appropriately.

TOPSEP:	program = 23400	(N = number of control parameters)
	blank common = $800 + 68(N) + (N)^2$	
GODSEP:	program = 23900	
	blank common = $100 + 9\ (NDIM)^2$	(if STM created)
	$= 100 + 9\ (NDIM)^2 + 5\ (NAUG)^2$	(if STM used)
	$= 100 + 13\ (NAUG)^2$	(if PDOT used)
SIMSEP:	program = 39100	(N = number of guidance events)
	blank common = $900 + N(NAUG)^2$	
REFSEP:	program + blank common = 21000	

2.1 Trajectory - $TRAJ Input Description

The namelist $TRAJ, which is read in by DATAM, contains reference trajectory and spacecraft related information for ballistic or low thrust missions. Many of the variables have adequate default values such that the user only has to input those which are different. The variables are grouped as either trajectory, spacecraft or miscellaneous parameters.

Namelist $TRAJ:

a) Trajectory Parameters:

Variable	Dim	Default	Units	Definition
STEP	**1**	**0.05**	**-**	**Scaling factor of the integration step size.**
BØDYIN	**16x1**			**This array allows the user to input ephemeris data for a body that is not already included in MAPSEP (Planet Code is 10). The default values are those of the comet Encke. Orbital elements are of the form $X(t) = X_o + \alpha t$ where X_o is a constant, α is the rate of change and t is the time in Julian Centuries.**
BØDYIN(1)		**2444580.0**	**days**	**Julian date of ephemeris epoch.**
BØDYIN(2)		**500.0**	**km**	**Mean equational radius.**
BØDYIN(3)		**1000.0**	**km**	**Radius of the sphere of influence.**
BØDYIN(4)		**10^{-9}**	**km^3/sec^2**	**Gravitational constant.**

Variable	Dim	Default	Units	Definition
BØDYIN(5)		33180812.67	km	Semi-major axis (a).
BØDYIN(6)		0.0	Km/J.C.*	Time derivative of the semi-major axis.
BØDYIN(7)		0.847		Eccentricity (e).
BØDYIN(8)		0.0	1/J.C.	Time derivative of the eccentricity.
BØDYIN(9)		11.95	deg	Inclination of the orbit plane (i).
BØDYIN(10)		0.0	deg/J.C.	Time derivative of the inclination.
BØDYIN(11)		334.2	deg	Longitude of the ascending node (Ω).
BØDYIN(12)		0.0	deg/J.C.	Time derivative of Ω.
BØDYIN(13)		160.2	deg	Longitude of periapsis (ω).
BØDYIN(14)		0.0	deg/J.C.	Time derivative of ω .
BØDYIN(15)		0.0	deg	Mean Anomaly (M) at ephemeris epoch.
BØDYIN(16)		0.0	deg/J.C.	Mean motion ($\bar{n}$); computed internally if input is zero.
DRMAX	1	10^3	km	Maximum deviation from the reference conic before rectification.
FRCA	1	0.4	-	Scale factor of the target planet semi-major axis used as the maximum S/C-target distance below which the closest approach test begins; this avoids local minima, or "false" closest approaches, especially for inner planet missions.

* - J.C. is a Julian Century (36525 days exactly).

Variable	Dim	Default	Units	Definition
IAUGDC	10	10*0	-	Flags used to identify the augmented dynamic state for GODSEP in the STM file generation submode. Non-zero entries will activate a parameter.
IAUGDC(1)				S/C position and velocity vectors
IAUGDC(2)				Thrust bias: proportionality, cone and clock.
IAUGDC(3)				Heliocentric state of ephemeris body.
IAUGDC(4)				Gravitational constant of ephemeris body.
IAUGDC(5)				Gravitational constant of sun.
IAUGDC(6)				Not used.
IAUGDC(7)				Not used.
IAUGDC(8)				Not used.
IAUGDC(9)				Not used.
IAUGDC(10)				Not used.
ICØØRD	1	0	-	Planet code (see next page) of reference body of input state (STATE); positive values indicate 1950.0 ecliptic inertial coordinates; a value of -3 indicates geocentric equatorial coordinates.

CODE	PLANET
0	Sun
1	Mercury
2	Venus
3	Earth
4	Mars
5	Jupiter
6	Saturn
7	Uranus
8	Neptune
9	Pluto
10	User Specified
11	Moon

Variable	Dim	Default	Units	Definition
ISTØP	1	1	-	The trajectory termination flag. There are four possible criteria for terminating the trajectory. = 1, final time (TEND) = 2, closest approach = 3, sphere of influence = 4, stopping radius (RSTØP).
NB	11	11*0	-	This array is used to input the bodies to be considered in the trajectory propagation. The entries in NB, correspond to the non-zero values of the planet codes. The sun is automatically included.
NEP	1	0	-	Planet code of ephemeris body in IAUGDC(3); internally set to NTP if entered as zero.
NTP	1	0	-	The planet code of the target body.
RSTØP	1	31096.5	km	The stopping radius must be specified when ISTØP is set to 4. The default value is set for a synchronous Earth orbit.
STATE	6	6*0.0	km, km/sec	The initial position and velocity vector of the spacecraft. (See ICØØRD).
TEND	1	0.0	days	The trajectory termination time, t_{final}, relative to launch. The input may be full Julian Date or days from launch.
TLNCH	1	0.0	days	The Julian Date of the trajectory epoch (launch).

Variable	Dim	Default	Units	Definition
TSTART	1	0.0	days	The trajectory time associated with the input state. This can be a Julian Date or days from launch.
XBØDY	1	6HENCKE	-	Hollerith label for the input body (BØDYIN).

b) Spacecraft Parameters:

Variable	Dim	Default	Units	Definition
ENGINE	20			This array defines the spacecraft thrust subsystem (Section 4.1, Reference 1).
ENGINE(1)		21.65	KW	Useful power from the solar array at 1 AU (P_o).
ENGINE(2)		.65	KW	Housekeeping power (P_{HK}).
ENGINE(3)		21.65	KW	Maximum power when $r \leq r_{min}$ (P_{max}). See ENGINE(9).
ENGINE(4)		1.4382	-	Power Constant (C_1).
ENGINE(5)		0.0	-	Power Constant (C_2).
ENGINE(6)		-0.2235	-	Power Constant (C_3).
ENGINE(7)		0.0	-	Power Constant (C_4).
ENGINE(8)		-0.2147	-	Power Constant (C_5).
ENGINE(9)		1.0	AU	Heliocentric distance for which the power is a maximum (r_{min}).
ENGINE(10)		29.418	km/sec	Ion exhaust velocity (c).
ENGINE(11)		1.0	-	Thruster efficiency (η).
ENGINE(12)		0.0	1/sec	Power loss (P_L).
ENGINE(13)		0.0	days	Time decay of power loss prior to start of the mission.

Variable	Dim	Default	Units	Definition
ENGINE(14)		-	-	Not used.
ENGINE(15)		-1.0	$(\text{meters})^2$	Radiation pressure coefficient times the effective cross-sectional area of the solar arrays ($C_R A$). If negative, no radiation pressure.
ENGINE(16)		1.0	-	Scale factor on ENGINE(15) when $r < r_{min}$.
IENRGY	1	1	-	This flag determines the type of power subsystem. 0 - Ballistic 1 - Solar Electric Power 2 - Nuclear Electric Power
SCMASS	1	2000.0	kg	Spacecraft mass at TSTART.
THRUST	10x20			This array defines the thrust control policy for the trajectory. Each column contains the controls for each segment of the trajectory for i = 1 to 20 segments. (Section 4.1, Reference 1).
THRUST(1,i)		9.0, 19*0.	-	= 0.0, last thrust phase; = 1.0, the thrust coordinate system is Cone and Clock angle; = 2.0, the thrust coordinate system is In Plane and Out of Plane angles; = 9.0, coasting.
THRUST(2,i)		$20*10^{20}$	days	Days from launch for which the i^{th} phase ends.
THRUST(3,i)		20*1.0		Throttling level (T_L).
THRUST(4,i)		20*0.0	deg	Cone angle when THRUST(1,i) = 1.0. In plane angle when THRUST(1,i) = 2.0.
THRUST(5,i)		20*0.0	deg	Clock angle when THRUST(1,i) = 1.0. Out of plane angle when THRUST(1,i) = 2.0.

Variable	Dim	Default	Units	Definition
THRUST(6,i)		20*0.0	deg/sec	Cone angle rate when THRUST (1,i) = 1.0. In plane angle rate when THRUST(1,i) = 2.0.
THRUST(7,i)		20*0.0	deg/sec	Clock angle rate when THRUST (1,i) = 1.0. Out of plane angle rate when THRUST(1,i) = 2.0.
THRUST(8,i)		20*1.0	-	The number of thrusters. This is required only for GØDSEP and SIMSEP.
THRUST(9,i)		-	-	Not used.
THRUST(10,i)		-	-	Not used.
ZK		0, 0, 1	-	Direction cosines of the star used as a reference for the Cone and Clock system. Default value is the south ecliptic.

c) Miscellaneous Parameters

Variable	Dim	Default	Units	Definition
EDIT	50	50*0.0	-	This array is used for storage related to temporary program modifications.
IPRINT	1	0	-	This flag controls trajectory print. > 0, Print every IPRINT integration steps. = 0, No print. = -1, Print every XPRINT days. = -2, Print every event. IPRINT = -1 should rarely be used, especially in the GØDSEP mode. It is suggested to set IPRINT = 20000. The result will be prints at

Variable	Dim	Default	Units	Definition
				initialization, at every primary body and thrust control phase change, and at termination.
ISTMF	1	1	-	This flag is used in conjunction with the STM file and the namelist $TRAJ. = 0, Ignore. = 1, Write the namelist $TRAJ onto disc; create the STM file if the mode is GODSEP. = 2, Read $TRAJ from disc; read the STM file if the mode is GODSEP. = 3, The same as 2, but also read the a-priori covariances from the GAIN file if the mode is GODSEP. = 4, Read $TRAJ from disc and update with a <u>second</u> input $TRAJ namelist.
MØDE	1	2	-	This flag indicates the operating mode of MAPSEP. Positive values will recycle back to MAPSEP main, while negative numbers will return to the main of the mode. This feature allows the user to run stacked cases. = ±1, Targeting and Optimization (TØPSEP). = ±2, Error Analysis (GØDSEP). = ±3, Simulation (SIMSEP).
PRNML	1	F	-	Do (T), do not (F) print input namelist $TRAJ
XPRINT	1	10^{20}	days	Trajectory print frequency. Must be specified when IPRINT = -1 (MPRNT = -1 in $TØPSEP)

d) REFSEP Parameters

Variable	Dim	Default	Units	Definition
ELVMIN	1	0.	deg	Minimum elevation angle for tracking S/C or target body
IØBS	1	9	-	Column in STALØC array containing the station location of the astronomical observatory (see STALØC below)
KARDS	1	0	-	Number of formatted print schedule cards to be read in after the $TRAJ namelist
STALØC	3x9		Mixed	Array of station locations in either of the following sets of units (if STALØC (1,I)>90., then cylindrical coordinates are assumed, otherwise, spherical). STALØC (1,I) = spin radius (km) STALØC (2,I) = longitude (deg) STALØC (3,I) = Z-height (km) or STALØC (1,I) = latitude (deg) STALØC (2,I) = longitude (deg) STALØC (3,I) = altitude (km) default stations are: 1 - Goldstone (5200.234, - 116.833, 3693.429) 2 - Madrid (4855.414, -3.667, 4134.766) 3 - Canberra (5204.135, 149.136, -3686.233) 9 - Kitt Peak (4185.171, 250.000, 4814.489 Note: STALØC is also an input parameter to $GØDSEP with the same meaning.

2.2 TOPSEP Input Description

The input for the TOPSEP mode is transmitted via the namelists $TRAJ and $TØPSEP. $TRAJ contains the basic trajectory and spacecraft information for a nominal low thrust mission. $TØPSEP contains the necessary parameters to alter the nominal trajectory in order to obtain a more desirable trajectory. All namelist vairables assume the program default values if they are not specified by input. In addition, once a variable has been set by namelist input or by default, it will resume that value at the beginning of all succeeding stacked cases even though the value may have been changed by the program during any one stacked case.

Namelist $TØPSEP:

Variable	Dim	Default	Units	Definition
BTØL	1	.05	-	Tolerance on control bounds within which a modified control correction may be implemented (See Page 143). The tolerance region within the minimum and maximum bounds (ULIMIT(I,1),ULIMIT (I,2)) is defined by BTØL x (ULIMIT(I,2)-ULIMIT(I,1)).
DFMAX	1	1000.	-	Maximum increase allowed in the cost index per iteration (decimal percent of nominal cost index value) (See Page 146)
DP2	1	0.04	-	Estimated region of linearity (See Page 150).

Variable	Dim	Default	Units	Definition
EPSØN	1	0.0	-	Scalar multiple for control perturbation; if no acceptable control step, then a new sensitivity matrix will be calculated based upon the revised perturbations H(I,J) = H(I,J) X EPSØN.
G	20x1	20*0.0		Performance gradient (may be input if available from a previous computer run) (See Page 146).
GTRIAL	5x1			One-dimensional search constants (See Page 144). Let P = P (γ) be the function to be minimized (the cost index and/or the error index) and γ be the step size scale factor to be optimized, then
GTRIAL(1)		0.1	-	$\frac{\gamma_{i+1}}{\gamma_i}$ may not be less than x GTRIAL(1).
GTRIAL(2)		5.0	-	γ_i may not be greater than GTRIAL(2).
GTRIAL(3)		0.01	-	If the Δ% of γ_{i+1} to γ_i is less than GTRIAL(3) then P(γ) is considered minimized.
GTRIAL(4)		1.E-15	-	If the Δ% of the estimated P_i to the actual P_i is less than GTRIAL(4) then P(γ) is considered minimized.
GTRIAL(5)		4.0	-	Real flag designating the extent of the curve fitting in the new control direction. = 1., two-point-one-slope fit; = 2., three-point-one-slope fit; = 3., three-point fit; = 4., four-point fit. (e.g., GTRIAL(5) = 4. indicates that all four curve fitting techniques may be applied in the preceding order).

Variable	Dim	Default	Units	Definition	
H	10x22	220*0.	Mixed	Array of control designations. A non-zero value indicates the associated parameter is a control. If IASTM ≠ 0, values of H are perturbations used in finite differencing. IASTM = 1, values of H are used only as activating flags. The first 20 columns of H correspond to elements of the THRUST array (See Page 10) (e.g., H (4,1) = .1 identifies the cone angle of the first phase as a control. Note: THRUST (I,J), I = 2,7 and J = 1,20 are the only valid thrust controls). The last two columns of H correspond to the parameters listed below. When the grid mode is operative the H array represents the first step for the selected controls (See HMULT for designating second step). <u>Parameters Selected as Controls</u>	
H(1,21)			km	x, STATE(1)	
H(2,21)			km	y, STATE(2)	
H(3,21)			km	z, STATE(3)	Geocentric or
H(4,21)			km	r, STATE(7)	Heliocentric
H(5,21)			km/sec	$\dot{x}$, STATE(4)	Ecliptic
H(6,21)			km/sec	$\dot{y}$, STATE(5)	Initial State
H(7,21)			km/sec	$\dot{z}$, STATE(6)	
H(8,21)			km/sec	v, STATE(8)	
H(9,21)			km	radius of parking orbit, r_o	
H(10,21)			deg	inclination of parking orbit, i	
H(1,22)			sec	injection time in parking orbit, t_o	See
H(2,22)			km/sec	injection Δv	Ref.1
H(3,22)			deg	in-plane $\underline{\Delta v}$ direction angle, χ	P.124
H(4,22)			deg	out-of-plane $\underline{\Delta v}$ direction angle, ψ	
H(5,22)			kw	base power at 1 au, ENGINE (1)	
H(6,22)			km/sec	exhaust velocity, ENGINE (10)	
H(7,22)			kg	initial mass, SCMASS	
H(I,22)			-	I = 8,10 ; not used	

Variable	Dim	Default	Units	Definition
HMULT	20	20*0	-	Scalar multiple of non-zero elements of the H array (max of 20) used to define the second step in the grid mode. See p. 138.
IASTM	1	1	-	Flag designating the method of computing the targeting sensitivity matrix = 0, finite differencing by means of perturbed trajectories = 1, integrated state transition matrices If IASTM = 1 the parameters available as controls are restricted. See Page 140.
IMØDE	1	2	-	TØPSEP submode designation. = 1, reference trajectory propagation. = 2, target and optimize. = 3, generate trajectory grid.
INSG	1	0	-	If flag set to 1, then target sensitivities S and the performance gradient G are input; if flag left 0, ignore (See Page 146).
IWATE	1	1	-	Type of control weighting (See Page 141-A). = 1, unity weighting. = 2, normalized control weighting. = 3, sensitivity weighting. = 4, combined sensitivity, target error, and control weighting. = 5, target gradient weighting. = 6, averaged gradient and control weighting.
JWATE	1	0	-	Target weighting flag (See P. 142) = 0, do not weight target variables. = 1, use tolerances to weight targets.

Variable	Dim	Default	Units	Definition
MPRINT	10x1	10*0	-	Print option flags. =-1, print every XPRINT days and at control phase and primary body changes. = 0, no trajectory print. = I, print every I integration steps. MPRINT(1), reference trajectory and grid print. MPRINT(2), perturbation trajectory print. MPRINT(3), trial trajectory print. MPRINT(4), supplementary print for targeting mode. MPRINT(5) - (10), not used.
NMAX	1	1	-	Maximum number of iterations allowed.
ØPTEND	1	89.999	deg	Optimization termination angle; optimization is considered complete when $\cos\theta = \frac{\underline{G} \cdot \Delta \underline{U}_2}{\lvert\underline{G}\rvert \times \lvert\Delta \underline{U}_1\rvert}$ approaches 0 (when θ approaches 90 deg). If ØPTEND $< \theta <$ 90 optimization is considered complete. If ØPTEND is set to 0 deg TOPSEP will generate a targeted but not optimized trajectory.
ØSCALE	1	1.0	-	Scale on performance index for simultaneous targeting and optimization (See P. 149).
PCT	1	0.2	-	Fraction of target error to be removed in the first iteration (See P. 143).
PRNML	1	F	-	Do (T), do not (F) print input namelist $TØPSEP

Variable	Dim	Default	Units	Definition
S	6x20	120*0.0	Mixed	Target sensitivities (may be input if available from previous computer run) See Page 146.
STØL	1	0.001	-	Minimum difference allowed between the inner products of the columns of the sensitivity matrix and the inner product of exactly linearly dependent vectors. If $\underline{S}_1$ and $\underline{S}_2$ represent the first two columns of the S matrix and $1 - \left[\frac{\underline{S}_1 \cdot \underline{S}_2}{\lvert\underline{S}_1\rvert * \lvert\underline{S}_2\rvert}\right] < \text{STØL}$ then the two columns are considered linearly dependent and the control associated with one of the columns (U(1) or U(2)) will be dropped from further consideration during the current iteration. (See Page 142)
TARGET	6x1	6*0.0	Mixed	Target values; must be input in the same numerical order as indicated by the index on the TARTØL vector.
TARTØL	25x1	25*0.0		Vector of target tolerances; a non-zero value of any component indicates that the associated target parameter will be included in the targeting process. The desired target value is input in TARGET. The targets are evaluated at the stopping condition. (ISTØP in $TRAJ). The associated target parameters with respect to the target body are as follows.
TARTØL(1)			km	(1) x-comp of target body relative state.
TARTØL(2)			km	(2) y-comp of target body relative state.

Variable	Dim	Default	Units	Definition
TARTØL(3)			km	(3) z-comp of target body relative state.
TARTØL(4)			km	(4) $\lvert \underline{r} \rvert$, radial distance from target body.
TARTØL(5)			km/sec	(5) $\dot{x}$-comp.
TARTØL(6)			km/sec	(6) $\dot{y}$-comp.
TARTØL(7)			km/sec	(7) $\dot{z}$-comp.
TARTØL(8)			km/sec	(8) $\lvert \underline{v} \rvert$, velocity magnitude.
TARTØL(9)			km/sec	(9) V_{HP}, hyperbolic excess velocity.
TARTØL(10)			km	(10) RCA, radius of closest approach.
TARTØL(11)			km	(11) $\underline{B}\cdot\underline{T}$, B-plane coordinate.
TARTØL(12)			km	(12) $\underline{B}\cdot\underline{R}$, B-plane coordinate.
TARTØL(13)			days	(13) TSØI, time at sphere of influence.
TARTØL(14)			days	(14) TRCA, time at closest approach.
TARTØL(15)			km	(15) a, semi-major axis.
TARTØL(16)			-	(16) e, eccentricity.
TARTØL(17)			deg	(17) i, inclination.
TARTØL(18)			deg	(18) Ω, longitude of ascending node.
TARTØL(19)			deg	(19) ω, argument of periapsis
TARTØL(20)			deg	(20) MA mean anomaly.
TARTØL(I)				I = 21,25 not used.

Variable	Dim	Default	Units	Definition
TLØW	1	1.0	-	Limit of quadratic error index (EMAG) below which optimization only is performed. (See Page 150).
TUP	1	1.0	-	Limit of quadratic error index (EMAG) above which simultaneous targeting and optimization is discontinued and targeting only is initiated. (See Page 150).
ULIMIT	20x2	$20*(-10^{20}, 10^{20})$	Mixed	Minimum and maximum bounds on the controls in the control vector. The units are the same as those of the controls (See Page 141-A).
UWATE	20x1	20*1.0	-	User input control weightings which are applied for all choices of the variable IWATE.

Tug Parameters

Variable	Dim	Default	Units	Definition
AZMAX	1	120.	deg	Maximum launch azimuth constraint for inner parking orbit (launch from Cape Kennedy)
AZMIN	1	35.	deg	Minimum launch azimuth constraint for inner parking orbit (launch from Cape Kennedy)
RP1	1	6567.26	km	Inner parking orbit radius
TGFUEL	1	10673.0	kg	Maximum weight of fuel for transfer stage
TUGISP	1	309.2	sec	Specific impulse of transfer stage
TUGWT	1	1714.6	kg	Dry weight of transfer stage

2.3 GODSEP Input Description

Three forms of input are used by the error analysis mode. The namelist \$GØDSEP is used to define output, all measurement and event information (except the scheduling of measurements and propagation events), and all covariance initialization and propagation information. Immediately following \$GØDSEP are NSCHED cards defining the scheduling of all measurements and propagation events. The format for these cards, as well as a definition of data type codes, appears after namelist \$GØDSEP is defined.

Following the measurement schedule cards are a series of optional namelists for guidance, each called \$GEVENT. Reading of \$GEVENT is controlled by the guidance flag array IGREAD, described in \$GØDSEP.

Reference is made below in the definitions of IPFØRM and IGFØRM to the "packed" and "unpacked" forms of a matrix. If the solve-for covariance matrix PS is dimensioned 10 x 10, but the current run has only 2 solve-for parameters, the 2 x 2 PS matrix is considered "packed" if the four covariance elements occupy the first four consecutive words of storage for the PS matrix. This can be achieved in namelist input by

PS = 9., .63, .63, 4.,

If, however, the namelist input contains

PS(1,1) = 9., PS(1,2) = .63,

PS(2,1) = .63, PS(2,2) = 4.,

the four elements of PS will occupy words 1, 2, 11, and 12 of the

PS matrix due to internal storage standards and the matrix is termed "unpacked."

2.3.1 Namelist $GØDSEP - Covariance Initialization and Propagation:

Variable	Dim	Default	Units	Definition
IPFØRM	1	0	-	= 0, input knowledge standard deviations and correlation co-efficients in packed form (see above for definition of packed and unpacked) = 1, input knowledge in unpacked form.
P	6x6	1000 km, 50 m/s each component		Standard deviations and correlation coefficients of state at epoch defined by TCURR
CXS	6x11	0	-	Correlations between state and solve-for parameters
CXU	6x13	0	-	Correlations between state and dynamic consider parameters.
CXV	6x15	0	-	Correlations between state and measurement consider parameters
CXW	6x10	0	-	Correlations between state and ignore parameters.
PS	11x11	0	-	Std. dev. and correlation coefficients of solve-for parameters
CSU	11x13	0	-	Correlations between solve-for and dynamic consider parameters
CSV	11x15	0	-	Correlations between solve-for and measurement consider parameters
CSW	11x10	0	-	Correlations between solve-for and ignore parameters

Variable	Dim	Default	Units	Definition
PU	13x13	0	-	Std. deviations and correlation coefficients of dynamic consider parameters
CUV	13x15	0	-	Correlations between dynamic consider and measurement consider parameters
CUW	13x10	0	-	Correlations between dynamic consider and ignore parameters
PV	15x15	0	-	Std. deviations and correlation coefficients of measurement consider parameters
CVW	15x10	0	-	Correlations between measurement considers and ignore parameters
PW	10x10	0	-	Std. deviations and correlation coefficients of measurement consider parameters
IGFØRM	1	0	-	Ignored if CØNRD =.FALSE.; if CØNRD =.TRUE., =0, input control uncertainties packed =1, input control uncertainties unpacked. (see above definitions of packed and unpacked)
PG CXSG CXUG CXVG CXWG PSG CSUG CSVG CSWG PUG CUVG CUWG PVG CVWG PWG				Standard deviations and correlations of control covariance (analgous to P, CXS, ..., PW); if CØNRD = .FALSE., then control covariance is set to a-priori knowledge; if CØNRD = .TRUE., then control must be input at epoch defined by TG.
CØNRD	1	F	-	=F, set apriori control to a priori knowledge =T, assume a-priori control read in namelist (See Page 159)

Variable	Dim	Default	Units	Definition
DYNØIS	1	T	-	=T, compute effective process noise matrix for use with state transition matrix propagation =F, don't compute effective process noise
SCMVAR	1	0.	kg	initial S/C mass standard deviation
EPSIG	3x2		mixed	Process noise standard deviations, used only for STM (not PDOT).
EPSIG(1,1)		.01	-	Std. dev. in magnitude proportionality noise
EPSIG(2,1)		.01	rad	Std. dev. in cone angle noise
EPSIG(3,1)		.01	rad	Std. dev. in clock angle noise
EPSIG(1,2)		0	-	Std. dev. in secondary process for magnitude proportionality
EPSIG(2,2)		0	rad	Std. dev. in secondary noise process for cone angle
EPSIG(3,2)		0	rad	Std. dev. in secondary noise process for clock angle
EPTAU	3x2		days	EPTAU (I,J) is correlation time for J^{th} noise process
EPTAU(1,1)		4	days	corresponding to EPSIG (I,J) and PDOT process noise (See Page 159)
EPTAU(2,1)		1	days	
EPTAU(3,1)		1	days	
EPTAU(1,2)		0	days	
EPTAU(2,2)		0	days	
EPTAU(3,3)		0	days	
IAUG	50	50*0	-	Parameter augmentation control IAUG(I) controls augmentation of parameters to state vector as follows =0, not used =1, parameter solved-for =2, parameter considered =3, parameter ignored (generalized covariance only) IAUG(I) parameters available (1) thrust acceleration proportionality (2) cone angle bias (3) clock angle bias

Variable	Dim	Default	Units	Definition
IAUG				(4) through (9) ephemeris planet elements, $x,y,z,\dot{x},\dot{y},\dot{z}$, if IEPHEM=0 or 1 a,e,i,Ω,ω,m, if IEPHEM=2 (10) ephemeris body gravitational constant (11) solar gravitation constant (12)-(17) used only if PDØT = TRUE (12) noise process corresponding to EPSIG(1,1) (13) noise process corresponding to EPSIG(2,1) (14) noise process corresponding to EPSIG(3,1) (15) noise process corresponding to EPSIG(1,2) (16) noise process corresponding to EPSIG(2,2) (17) noise process corresponding to EPSIG(3,2) (18) spin radius, station #1 (19) longitude, station #1 (20) z-height, station #1 (21),(22),(23) spin radius, longitude, z-height sta. #2 (24),(25),(26) spin radius, longitude, z-height, sta. #3 (27),(28) 2-way doppler, range bias from sta. #1 (29),(30) 2-way doppler, range bias from sta. #2 (31),(32) 2-way doppler, range bias from sta. #3 (33),(34) 3-way doppler, range bias from sta. # 1,2 (35),(36) 3-way doppler, range bias from sta. # 1,3 (37),(38) 3-way doppler, range bias from sta. # 2,3 (39),(40) azimuth, elevation angle biases from sta. #1 (41),(42) azimuth, elevation angle biases from sta. #2 (43),(44) azimuth, elevation angle biases from sta. #3 (45) star-planet angle bias star #1 (46) star-planet angle bias star #2 (47) star-planet angle bias star #3

Variable	Dim	Default	Units	Definition
				(48) apparent planet diameter angle bias (49) astronomical observation, right ascension angle (50) astronomical observation, declination angle
IEPHEM	1	0	-	indicates format of ephemeris parameters if any flagged = 0, time evolving cartesian = 1, stationary cartesian = 2, stationary Keplerian
PDØT	1	F	-	logical flag controlling covariance integration = T, propagate covariance by integration = F, propagate covariance by state transition matrix method
PRØPG	1	F	-	not used for input, overridden internally
SCHFTL	1	T	-	logical flag = T, failure to mesh on STM file within tolerances defined by TØLFØR and TØLBAK is total = F, mesh failure not fatal
TCURR	1	TSTART ($TRAJ)	days	Epoch for input knowledge uncertainties, referenced to TLNCH (if PDOT = .TRUE. and TCURR ≠ TSTART, (See Section 4.2.5).
TFINAL	1	TEND ($TRAJ)	days	Error analysis final time, referenced to TLNCH
TG	1	TCURR	days	Epoch for input control uncertainties if CØNRD = T and control epoch different from knowledge epoch
TØLBAK	1	1.0	days	Backward tolerance on meshing scheduled event times with STM file times
TØLFØR	1	.03	days	Forward tolerance on meshing scheduled event times with STM file times

Measurement Related Variables

Variable	Dim	Default	Units	Definition
CØRLØN	1	.9	-	Station-to-station longitude correlation for ground-based tracking stations
DØPCNT	1	12	Meas./Day	Nominal number of dopler measurements to be taken per day for scaling doppler noise (SIGMES(1) and SIGMES(3))
GAINCR	1	F	-	Controls GAIN file creation (See Page 162) = T, create GAIN file = F, do not create GAIN file
GENCØV	1	F	-	= F, current run not generalized covariance = T, generalized covariance run, forces IGAIN = 4
IGAIN	1	1	-	Defines OD filtering algorithm = 1, Kalman-Schmidt = 2, sequential weighted least squares = 3, User-supplied filter (See Analytic Manual, Section 6.4) = 4, read filter gain from GAIN file (TAPE 4)
NSCHED	1	0	-	Number of measurement and propagation event scheduling cards to follow namelist $GØDSEP
NST	1	3	-	Number of active DSN station locations defined in STALØC array
SIGLØN	1	3.0	meter	Standard deviation in longitude for equivalent station location errors
SIGMES	15		mixed	Array of measurement white noise standard deviations

SIGMES(1)	1.0	mm/sec/1 min sample	2-way doppler
SIGMES(2)	3.0	meter	2-way range
SIGMES(3)	.1	mm/sec/1 min sample	3-way frequency drift
SIGMES(4)	10.0	meter	3-way range

Variable	Dim	Default	Units	Definition
SIGMES(5)		1600.	μ-rad	azimuth angle
SIGMES(6)		1600.	μ-rad	elevation angle
SIGMES(7)		150.	μ-rad	on-board optics -- star planet angle
SIGMES(8)		150.	μ-rad	on-board optics -- apparent planet diameter
SIGMES(9)		10.	km	on-board optics -- center-finding uncertainty; used in conjunction with star-planet angle
SIGMES(10)		3.	arc-sec	astronomical observation -- right ascension
SIGMES(11)		3.	arc-sec	astronomical observation -- declination
SIGMES(12)-(15)		-	-	not used
SIGRS	1	1.5	meter	standard deviation in spin radius for equivalent station errors
STALØC	3x9		mixed	array of station locations (cylindrical coordinates only) STALØC(1,I) = spin radius (km) STALØC(2,I) = longitude (deg) STALØC(3,I) = z-height (km) default values for station coordinates are: 1 - Goldstone (5200.234, -116.833, 3693.429) 2 - Madrid (4855.414, -3.667, 4134.766) 3 - Canberra (5204.135, 149.136, -3686.233) 9 - Astronomical Observatory (Kitt Peak = 4185.171, 250.000, 4814.489)
STARDC	3x9		-	array of ecliptic star direction cosines (or, equivalently, unit vectors in star directions) used for star-planet angle measurements; vector locating Jth star loaded in Jth column of STARDC default values are (fictitious stars) STARDC(1,1) = .7, .6, .3873 STARDC(1,2) = .6, .7, .3873 STARDC(1,3) = .65, .65, .3937

Event Variables

Variable	Dim	Default	Unit	Definition
NEIGEN	1	0	-	Number of eigenvector events to be scheduled (maximum 10).
TEIGEN	10	10*0.	days	Array of eigenvector event times (See Page 158).
NPRED	1	0	-	Number of prediction events to be scheduled (maximum 10)
TPRED	10	10*0.	days	Array of prediction event times
TPRED2	10	10*0.	days	Array of times predicted to
NGUID	1	0	-	Number of guidance events to be scheduled (maximum 20)
TGUID	20	20*0.	days	Array of guidance event execution times
TDELAY	20	20*0.	days	Array of guidance event delay times. Guidance events are scheduled at execution time minus delay time, and covariances are propagated forward to execution time.
TCUTØF	20	20*0.	days	Array of guidance event cutoff times for impulsive maneuvers, set TCUTØF(I) = TGUID(I)
IGPØL	20	20*0.	-	Array of guidance policy control flags = 0, no maneuver, print control uncertainties = 1, target to cartesian state, X,Y,Z at time specified by TIMFTA = 2, B·T, B·R targeting = 3, B·T, B·R, time at sphere targeting = 4, closest approach targeting (radius of closest approach, inclination, time of closest approach) = 5, variable time of arrival (XYZ targeting)
IGREAD	20	20*0.	-	Array of guidance event read control flags (if non-zero, control weights CØNWT will be read), See Page 163.

Variable	Dim	Default	Unit	Definition
				= 0, do not read namelist $GEVENT = 1, read namelist $GEVENT, and recompute control and target variation matrices (VMAT and SMAT) = 2, read $GEVENT
NCØN	1	4	-	Number of controls for low thrust guidance (must be greater than or equal to number of target variables). Controls are ordered: magnitude cone clock cutoff time start-up time (or arrival time if IGPØL = 5) = 1, magnitude only = 2, magnitude and cone = 3, magnitude, cone, clock = 4, magnitude, cone, clock, cutoff time = 5, use all five controls
CØNWT	5	5*1.	-	Relative weighting factors for controls defined by NCØN Small number weights out effect of control. CØNWT may also be re-defined in namelist $GEVENT
UMAX	5	5*50.	%, deg, day	Maximum allowable (1σ) control correction as defined by NCØN
TARWT	3	3*1.	-	Relative weighting factors for target parameters defined by IGPØL
TGSTØP	1	TEND ($TRAJ)	days	Stop time for integration of variation matrix if sphere or closest approach not reached in B-plane or closest approach targeting
TIMFTA	1	0.	days	Stop time for XYZ targeting (overrides TFINAL and TGSTØP).
SIGDV	4		mixed	Array of standard deviations defining impulsive ΔV execution errors
SIGDV(1)		.01	-	Standard deviation of proportionality error
SIGDV(2)		2.E-4	km/s	Standard deviation of resolution error

Variable	Dim	Default	Unit	Definition
SIGDV(3)		.065	rad	Standard deviation in ecliptic pointing angle
SIGDV(4)		.065	rad	Standard deviation in out of ecliptic pointing angle

Output Control

Variable	Dim	Default	Unit	Definition
CHEKPR	10	10*F	-	Array of logical flags controlling check point options which may be useful in debugging. The following elements of CHEKPR are activated if set equal to .TRUE.: (1) - writes on nominal output file (TAPE 6) all information on STM file (TAPE 3) during file generation and all information reads from the STM file. In addition, the results of each transition matrix chaining operation in subroutine STMRDR (See Program Manual) is also printed. (2) - Prints every measurement. (3) - Prints full covariance, not standard deviations and correlation coefficients, before and after each measurement. (4) - Writes on nominal output file (TAPE 6) all information written on GAIN file (TAPE 4) during creation, and all information read from GAIN file for IGAIN = 4 option. (5) - Writes on nominal output file (TAPE 6) knowledge and control uncertainties at end of burn interval and transition matrix over burn interval for low thrust guidance, or eigenvalues and eigenvectors of expected ΔV covariance for impulsive guidance.

Variable	Dim	Default	Unit	Definition
				(6) - computer time computation and display (7) - not used (8) - reads from STM file to compute transition matrices needed for guidance rather than calling TRAJ (9) - Prints covariance before and after each propagation (10)- dump core when mission time ≥ EDIT(50)
EDIT(50)	1	0	days	dump time (See CHEKPR(10))
IPRØP	1	0	-	Propagation event print control = 0, no print = 1, print standard deviations and correlation coefficients of S/C state only = 2, full eigenvector event
JØBLAB	10	Blank	-	Hollerith label to be printed with each measurement and event print
MPFREQ	12	12*0	-	Measurement print frequency control. If MPFREQ(I) = N, the first time the data type corresponding to MPFREQ(I) is scheduled it is printed. Thereafter, that data type will be printed each time its count is divisible by N. The following correspondences between MPFREQ and data type are used. (See also Section 2.3.2). (1) - two-way doppler (code 100X) (2) - three-way doppler (code 11XX) (3) - simultaneous 2-way/3-way doppler (code 12XX) (4) - differenced 2-way/3-way doppler (code 13XX) (5) - two-way range (code 200X) (6) - three-way range (code 21XX) (7) - simultaneous 2-way/3-way range (code 22XX) (8) - differenced 2-way/3-way range (code 23XX) (9) - azimuth-elevation angles (code 30XX and 300X). (10)- star-planet angles (code 4XXX, 40XX and 400X). (11)- apparent planet diameter (code 5000). (12)- astronomical observations (code 600X)
PRNCØV	5		-	Print control for standard deviations and correlation coefficients. (T = TRUE, F = FALSE)

Variable	Dim	Default	Units	Definition
PRNCØV(1)		T	-	Do (T) or do not (F) print state standard deviations and correlation coefficients and correlations with all augmented parameters
PRNCØV(2)		T	-	Do (T), do not (F) print solve-for standard deviations and correlation coefficients and correlations with other parameters
PRNCØV(3)		F	-	Do (T), do not (F) print standard deviations and correlation coefficients for dynamic consider parameters and correlations with other parameters.
PRNCØV(4)		F	-	Do (T), do not (F) print standard deviations and correlation coefficients for measurement consider parameters and correlations with ignore parameters
PRNCØV(5)		F	-	Do (T), do not (F) print standard deviations and correlation coefficients for ignore parameters
PRNML	1	F	-	Do (T), do not (F) print input namelist $GØDSEP after reading
PRNSTM	5		-	Print control for state transition matrix partitions. The flagging of any PRNSTM element causes prints, with each state transition matrix print, of the sensitivity of the relevant parameter set to the entire augmented state vector.
PRNSTM(1)		T		Prints sensitivities for S/C state
PRNSTM(2)		F		Prints sensitivities for solve-for parameters
PRNSTM(3)		F		Prints sensitivities for dynamic consider parameters
PRNSTM(4)		F		Prints sensitivities for measurement consider parameters

Variable	Dim	Default	Unit	Definition
PRNSTM(5)		F		Prints sensitivities for ignore parameters
PUNCHE	5	5*F		Punch flag for complete knowledge or control standard deviations and correlation coefficients at events = T, causes punching = F, does not Elements of PUNCHE are: (1) - knowledge at propagation event (2) - knowledge at eigenvector event (3) - knowledge at thrust event (4) - knowledge at time TPRED2 for prediction events (5) - control before and after maneuver at each guidance event
SUMARY	1	T	-	= T, write SUMMARY file (TAPE 8) = F, do not write SUMMARY file (TAPE 8)

2.3.2 Measurement and Propagation Schedule Input

Measurement schedule cards follow directly behind namelist $GØDSEP. Each card contains three time control variables in Columns 1-30 in format 3F10.4 and one measurement code (MESCØD) right justified in Column 40 (format I10).

Time control variables are START, STØP, DELT

START = start time, referenced to TLNCH, for scheduling current data type;

STOP = stop time for current data type;

DELT = time interval increment for scheduling.

For example, if START = 10.5, STØP = 20. DELT = 1.0, the current data

type will be scheduled ten times at 10.5, 11.5, 12.5, ..., 19.5 days. Internal tests modify START if it is less than TCURR, and STØP if it is greater than TFINAL so that no measurements are scheduled outside the requested error analysis interval.

One additional option is available on scheduling. Any scheduling card on which DELT is zero or negative redefines the allowable scheduling interval from (TCURR, TFINAL) to the (START, STOP) interval defined by that card. All succeeding measurements are scheduled in the interval defined by that card until another card with a zero or negative DELT is encountered.

If DELT is greater than zero and no measurement code appears (MESCØD = 0), propagation events will be scheduled. Except for propagation events, all other allowable measurement codes are 4-digits, defined as follows (station and star numbers are defined in STALØC and STARDC, respectively):

100n	2-way doppler (range-rate) from Station n;
11mn	3-way doppler from Stations m and n;
12mn	simultaneous 2-way/3-way doppler from Stations m and n;
13mn	differenced 2-way/3-way doppler from Stations m and n;
200n	2-way range from Station n;
21mn	3-way range from Stations m and n
22mn	simultaneous 2-way/3-way range from Stations m and n;
23mn	differenced 2-way/3-way range from Stations m and n

300n	azimuth and elevation measured from Station n;
300m	azimuth and elevation measured simultaneously from Stations m and n;
400n	on-board optics, angle measurement between ephemeris body and star n, defined by n^{th} column in STARDC array;
40mn	two simultaneous star-planet angle measurements with ephemeris body and Stars m and n
4kmn	three simultaneous star-planet angle measurements with ephemeris body and Stars k, m and n;
5000	apparent planet diameter measurement of ephemeris body.
600n	right ascension/declination measurement of ephemeris body from Station n.

2.3.3 Namelist $GEVENT

One copy of namelist $GEVENT must appear after the measurement schedule cards for each guidance event which has its corresponding value of IGREAD greater than zero. Default values are nominal input or computed values prior to reading $GEVENT.

Variable	Dim	Default	Units	Definition
BURNP	4	4*0.	km/s, Kg	Thrust acceleration and mass at beginning and at end of guidance interval (See Page 163).
CØNWT	5	-	-	See namelist $GØDSEP
NCØN	1	-	-	See namelist $GØDSEP

Variable	Dim	Default	Units	Definition
SMAT	3x5	15*0.	mixed	Sensitivity matrix of target parameters WRT control parameters (See Page 163).
TARWT	3	-	-	See namelist $GØDSEP
UMAX	5	-	-	See namelist $GØDSEP
VMAT	3x6	18*0.	mixed	Variation matrix of target parameters WRT state at guidance epoch (See Page 163).

2.4 SIMSEP Input Description

Input to the simulation mode is transmitted to the program through three namelists: $TRAJ, $SIMSEP, and $GUID. As before, the $TRAJ namelist essentially defines the reference trajectory initial conditions, spacecraft parameters (thrust, mass, electric power, etc.) and other baseline quantities necessary to specify a reference mission. In general, the $TRAJ inputs for SIMSEP are obtained as results from a precursor TOPSEP analysis where a targeted reference trajectory has been determined.

The first namelist peculiar to the SIMSEP mode is called $SIMSEP. Its primary function is to initialize a priori statistical descriptions of those error sources which remain nearly constant during the course of an individual simulation in the basic Monte Carlo cycle. In addition, various parameters which, for example, specify the number of guidance events, the output frequency, the number of Monte Carlo cycles, etc., are also read from $SIMSEP.

The second of these namelists unique to SIMSEP is $GUID. As its name implies, it is responsible for initializing parameters and data used at guidance events. Unlike $SIMSEP which is read only once for each SIMSEP run, $GUID is read for each specified guidance event being simulated along the mission. Variables initialized by this namelist include such things as guidance event times, knowledge covariances, guidance law and policy specifications, etc.

Finally, it should be noted that both $SIMSEP and $GUID can also contain certain statistical arrays computed in previous SIMSEP analyses.

These arrays are key to SIMSEP's restart capability and provide the means to continue an analysis with many more Monte Carlo cycles in a series of SIMSEP runs. The format for input is, generally, a (nxn) correlation matrix of standard deviations and correlation coefficients. An extra column vector augmented to the right hand side of the (nxn) matrix, thus creating a (nx(n+1)) matrix, serves to store mean values to complete the statistical description for the parameter of interest. Unfortunately, the multitude of options available in SIMSEP make the real numerical format used for input a bit awkward. In particular, the variables, CCØVG, CNTCØV, TARCØV, etc., are actually read as one long column vector with separate columns in the correlation matrix being stored consecutively. This apparent difficulty is somewhat off-set by the fact that these arrays are ordinarily generated as output from a previous SIMSEP run and have automatically been punched in the requisite format.

Another important capability in SIMSEP which relates to the namelists $SIMSEP and $GUID is the multiple run or stacked case feature. In particular, once normal computer processing of a run is completed, the program automatically recycles to read $SIMSEP again if the $TRAJ variable, MØDE, has been set to a -3. When this occurs, only changes to $SIMSEP from the previous run need to be input. Likewise, the $GUID namelists are also read in the same sequence as they were for the first run. Guidance event data need not be read anew unless there are changes to a particular data set or if there are more guidance events in the second run. The only

drawback here is that a zero-data namelist, i.e., a $GUID card followed by a $END card, must be input for each event even though there may be no changes. This is also a requirement for the $SIMSEP namelist upon recycling.

Given below are detailed descriptions of the variables, dimensions and default values (where applicable) for both $SIMSEP and $GUID. The parameters are divided into appropriate groupings; for $SIMSEP: run definition, a-priori control and ephemeris errors, spacecraft parameter errors, and accumulated statistics and parameters; for $GUID: event initialization data, optional initialization data, guidance law and policy, knowledge error, guidance control data, and accumulated statistical data.

Namelist: $SIMSEP

Run Definition Parameters:

Variable	Dim	Default	Units	Definition
AØK	1	100.	-	Backup convergence tolerance for the weak convergence test.
CPMAX	1	10000.	sec	Computer processing time limit (See Page 175).
DVMXN	1	0.1	km/sec	Maximum magnitude allowed for a delta-velocity correction.
INREF	1	0	-	Option flag to indicate whether or not state variables, s/c mass, targets, etc. are to be read as input during the $GUID namelist read. = 0, No data input (computed internally). = 1, Input data.

Variable	Dim	Default	Units	Definition
				If INREF = 1, the variables listed under Optional Guidance Event Initialization Data must be input along with MEND and XEND (See Page 172 and 173). If INREF = 0, the optional guidance event data are automatically computed.
IØUT	1	1	-	Print output flag which activates printout for every IØUT Monte Carlo cycle.
IPUNCH	1	0	-	Punch output flag. = 0, no punched statistical arrays (covariance matrices and vector means) at the end of the run. = 1, punch.
IRAN	1	1	-	Monte Carlo random number seed to initiate the generation of random number from RANF. ≠ 0, regular Monte Carlo analysis. = 0, forced Monte Carlo sampling of one-sigma for all error sources.
NCYCLE	1	1	-	Number of Monte Carlo mission cycles to be executed.
NGUID	1	1	-	Total number of guidance events, both low thrust and impulsive velocity changes, to be executed on each simulated mission. A maximum of five guidance events is allowed.
PRNML	1	F	-	Do (T), do not (F) print input namelist $SIMSEP after reading.

A Priori Control and Ephemeris Errors:

Variables	Dim	Default	Units	Definition
EPHERR	6x6x2	0,...,0	km, km/sec	Arrays describing the Cartesian ephemeris errors associated with at most two planets. A 6x6 array is read for each ephemeris planet with standard deviations along the principal diagonal and correlation coefficients off-diagonal. Only the principal diagonal and the lower triangular partition of the array are actually necessary.
GMERR	3		km^3/sec^2	One sigma uncertainties in the gravitational constants.
GMERR(1)		0.		Solar mass error.
GMERR(2)		0.		First ephemeris planet mass error.
GMERR(3)		0.		Second ephemeris planet mass error.
NEP2	2	0, 0		Array of ephemeris planet number codes to designate the active ephemeris error planets. The code convention is the same as that used in ØTRAJ for the NB array.
PG	6x6	0,...,0	km km/sec	Correlation array describing the *a priori* Cartesian control errors associated with the initial reference state vector. The input format is the same as EPHERR.
TEPH	2			Epochs at which ephemeris errors are evaluated.
TEPH(1)		0	days	Julian date or time from launch for the first ephemeris planet.

Variables	Dim	Default	Units	Description
TEPH(2)		0.	days	Julian date or time from launch for the second ephemeris planet.

S/C Parameter Errors:

Variables	Dim	Default	Units	Definition
EXVERR	4			One sigma midcourse velocity correction execution errors.
EXVERR(1)		0.	-	Proportionality error.
EXVERR(2)		0.	degs	In-ecliptic-plane pointing error.
EXVERR(3)		0.	degs	Out-ecliptic-plane pointing error.
EXVERR(4)		0.	km/sec	Resolution error.
SCERR	5			One sigma SEP s/c errors.
SCERR(1)		0.	kg	Initial s/c mass uncertainty.
SCERR(2)		0.	km/sec	Low thrust exhaust velocity uncertainty.
SCERR(3)		0.	kw	Uncertainty in electric power at 1 A.U.
SCERR(4)		0.	-	Uncertainty in thruster efficiency.
SCERR(5)		0.		Uncertainty in the effective radiation pressure coefficient.
TCERR	6x20	0,....,0		One sigma thrust control biases.
TCERR(1, j)			days	j^{th} thrust phase end time.
TCERR(2, j)			-	j^{th} thrust phase throttling.
TCERR(3, j)			degs	j^{th} thrust phase cone angle.
TCERR(4, j)			degs	j^{th} thrust phase clock angle.
TCERR(5, j)			degs/sec	j^{th} thrust phase cone angle rate.

Variables	Dim	Default	Units	Description
TCERR(6, j)			degs/sec	j^{th} thrust phase clock angle rate.
TVERR	6x3			One sigma time varying thrust control errors (dynamic process noise specifications), corresponding correlation times, and correlation time uncertainties for two simultaneous, independent processes.
TVERR(1, 1)		0.	-	First process, thrust proportionality uncertainty (per thruster).
TVERR(1, 2)		1.	days	Correlation time for thrust acceleration.
TVERR(1, 3)		0.	days	Uncertainty in the thrust acceleration correlation time.
TVERR(2, 1)		0.	degs	First process, cone angle uncertainty.
TVERR(2, 2)		1.	days	Correlation time for cone angle.
TVERR(2, 3)		0.	days	Uncertainty in the cone angle correlation time.
TVERR(3, 1)		0.	degs	First process, clock angle uncertainty.
TVERR(3, 2)		1.	days	Correlation time for clock angle.
TVERR(3, 3)		0.	days	Uncertainty in the clock angle correlation time.
TVERR(4, 1)		0.	-	Second process, thrust acceleration uncertainty (per thruster).
TVERR(4, 2)		1.	days	Correlation time for thrust acceleration.

Variables	Dim	Default	Units	Description
TVERR(4, 3)		0.	days	Uncertainty in the thrust acceleration correlation time.
TVERR(5, 1)		0.	degs	Second process, cone angle uncertainty.
TVERR(5, 2)		1.	days	Correlation time for cone angle.
TVERR(5, 3)		0.	days	Uncertainty in the cone angle correlation time.
TVERR(6, 1)		0.	degs	Second process, clock angle uncertainty.
TVERR(6, 2)		1.	days	Correlation time for clock angle.
TVERR(6, 3)		0.	days	Uncertainty in the clock angle correlation time.

Accumulated Statistics and Parameters:

Variable	Dim	Default	Units	Definition
ADVT	2			Accumulated delta-velocity magnitude statistics for all impulsive velocity corrections along a mission.
ADVT(1)		0.	km/sec	One-sigma delta-velocity magnitude.
ADVT(2)		0.	km/sec	Mean delta-velocity magnitude.
ENDCØV	6x7	0.,,,0.	km km/sec	S/C control error correlation array computed at the trajectory time TEND. This array is input as a (6x6) matrix of standard deviations and correlation coefficients. Only the principal diagonal and the lower triangular submatrix are necessary. The 7th column of this array contains the means.

Variables	Dim	Default	Units	Definition
AMASS	2			Accumulated S/C mass statistics at the final time.
AMASS(1)		0.	kg	One-sigma s/c mass.
AMASS(2)		0.	kg	Mean s/c mass.
MEND	1	0.	kg	Final s/c mass on the reference trajectory at time TEND. This variable is required only if INREF = 1 and is used in computing AMASS statistics.
MC	1	0.	-	Number of Monte Carlo cycles executed in a previous SIMSEP run in which statistical variables ADVT, AMASS, ENDCØV, and ATHCØV are computed. MC is used to restart accumulated statistics for the current run.
ATHCØV	420	0,...,0.		Accumulated statistics on the active thrust controls changed at scheduled low thrust guidance events. A maximum of twenty active thrust controls are allowed. This array is input as a (nxn) matrix of standard deviations and correlation coefficients, where n is the total number of low thrust controls. As before, only the principal diagonal and lower triangular submatrix need to be input. The $(n+1)^{th}$ column vector contains the means.
XEND	6	0,...,0.	km, km/sec	Final reference trajectory state vector at the trajectory time TEND. This vector is required input only if INREF = 1 and is used in computing the ENDCØV covariance matrix.

Variable	Dim	Default	Units	Definition
KATHC	1	0	--	Dimension of the ATHCØV matrix.

S/C Parameters for Midcourse Velocity Corrections:

Variable	Dim	Default	Units	Definition
SPFIMP	1	265.	sec	Specific impulse for chemical propulsion system.
DVMDØT	1	.05	kg/sec	Mass flow rate for chemical propulsion system.

Namelist: $GUID

Guidance Event Initialization Data:

Variable	Dim	Default	Units	Definition
KTER	1	0.	-	Option flag to indicate whether or not target errors are to be evaluated after the current guidance event. If KTER = 1, a trajectory is integrated from the point of the guidance event to the target.
TGUID	1	0.	days	Epoch of the current guidance event specified as either a Julian date or the interval of days since launch.
TTARG	1	0.	days	Designated epoch of arrival at the target specified either as a Julian date or as the interval of days since launch.

Optional Guidance Event Initialization Data: These variables are required input only if INREF = 1 (See $SIMSEP).

Variable	Dim	Default	Units	Definition
MGREF	1	0.	kg	S/C reference mass at the current guidance event.
MTREF	1	0.	kg	S/C reference mass at the designated target time.
S	36	0,...,0.	Mixed	Sensitivity or guidance matrix which has been computed in a previous analysis. For linear guidance, S is input as a guidance matrix. For nonlinear guidance, S is input as a targeting sensitivity matrix.

Variable	Dim	Default	Units	Definition
TARGET	6	0,...,0.	Mixed	Array of reference target values evaluated at the designated target time.
XGREF	6	0,...,0.	km, km/sec	Reference trajectory state vector at the current guidance event.
XTREF	6	0,...,0.	km, km/sec	Reference trajectory state vector at the designated target time.
PRNML	1	F	--	Do (T), do not (F) print namelist $GUID after reading.

Guidance Law and Policy Data:

Variable	Dim	Default	Units	Definition
IGUID	1	1	--	Guidance law flag. = -2, nonlinear, impulsive guidance. = -1, linear, impulsive guidance. = 0, zero-action guidance event with no maneuver performed but control statistics computed. = +1, linear, low thrust guidance event. = +2, nonlinear, low thrust guidance event.
ITARGT	25	0,....,0.	--	Target policy vector; a non-zero value of any component indicates that the associated target parameter will be included as a target variable. All targets are evaluated at the designated target time.
ITARGT(1)			km	X-component of the S/C state relative to the target body.
ITARGT(2)			km	Y-component of the S/C state relative to the target body.

Variable	Dim	Default	Units	Definition
ITARGT(3)			km	Z-component of the S/C state relative to the target body.
ITARGT(4)			km	$\lvert \underline{r} \rvert$ - radial distance from the target body.
ITARGT(5)			km/sec	V_x - component of the S/C state relative to the target body.
ITARGT(6)			km/sec	V_y - component of the S/C state relative to the target body.
ITARGT(7)			km/sec	V_z - component of the S/C state relative to the target body.
ITARGT(8)			km/sec	$\lvert \underline{v} \rvert$ - velocity magnitude relative to the target body.
ITARGT(9)			km/sec	v_{hp} - hyperbolic excess velocity.
ITARGT(10)			km	r_{ca} - radius of closest approach.
ITARGT(11)			km	B•T coordinate in the impact plane.
ITARGT(12)			km	B•R coordinate in the impact plane.
ITARGT(13)			days	TSOI, conically interpolated time of encountering the target sphere of influence relative to TLNCH.
ITARGT(14)			days	TRCA, conically interpolated time of arrival at closest approach relative to TLNCH.
ITARGT(15)			km	a, semi-major axis of the osculating conic relative to the target body.
ITARGT(16)			--	e, eccentricity of the osculating conic relative to the target body.

Variable	Dim	Default	Units	Definition
ITARGT(17)			deg	i, inclination of the osculating conic relative to the target body.
ITARGT(18)			deg	Ω, longitude of ascending node of the osculating conic relative to the target body.
ITARGT(19)			deg	ω, argument of periapsis of the osculating conic relative to the target body.
ITARGT(20)			deg	M, mean anomaly of the osculating conic relative to the target body.
ITARGT(21)			deg	f, true anomaly of the osculating conic relative to the target body.
ITARGT(22)-(25)			--	Not used.

Variable	Dim	Default	Units	Definition
NTP	1	0	--	Code flag defining the target planet for the current guidance event. (See Page 7).
TARTØL	6	0,....,0.	Mixed	Target tolerance array. When the miss for each target variable is less than or equal to the corresponding TARTØL value, the strong convergence criterion is satisfied.

Knowledge Error Data:

Variable	Dim	Default	Units	Definition
CXS	6x11	0,...,0.	-	Cross correlation array of solve-for parameters which have been augmented to the state vector.
KDIMEN	1	6	-	Dimension of the augmented state vector. = 6, s/c state vector only. = 7, s/c state vector and one mass (sun or a planet). = 8, s/c state vector and two masses (sun and a planet). = 9, s/c state vector and thrust biases (magnitude, cone and clock). = 10, s/c state vector, thrust biases, and one mass. = 11, s/c state vector, thrust biases, and two masses.

Variable	Dim	Default	Units	Definition
				= 12, s/c state vector and ephemeris planet errors $(X,Y,Z,\dot{X},\dot{Y},\dot{Z})$. = 13, s/c state vector, ephemeris errors, and one mass. = 14, s/c state vector, ephemeris errors, and two masses. = 15, s/c state vector, ephemeris errors, and thrust biases. = 16, s/c state vector, ephemeris errors, thrust biases, and one mass. = 17, s/c state vector, ephemeris errors, thrust biases and two masses.
P	6x6	0,...,0.	km, km/sec	Correlation array describing the Cartesian knowledge errors associated with the actual trajectory state at the guidance event. The input format is the same as EPHERR (See Page 41).
PS	11x11	0,...,0.	Mixed	Correlation array of solve-for parameters which have been augmented to the s/c state vector. The input format is the same as EPHERR (See Page 41).
NEP	1	0	-	Planet code (See Page 7) of ephemeris body, used only if ephemeris knowledge errors are present.

Guidance Event Control Parameters:

Variable	Dim	Default	Unit	Definition
H	10x20	0,...,0.	-	Array of flags used to identify the active thrust control variables to be used

Variable	Dim	Default	Units	Definition
				during the current low thrust guidance event. The entries in H have a one to one correspondence to elements in the THRUST array. (See Page 10). Comment: Only the first six non-zero entries will be used since a maximum of six controls at any given guidance event is allowed (See Page 170).
H(1,j)				Not used.
H(2,j)			days	Active thrust control is the j^{th} thrust phase end time (THRUST(2, j)).
H(3,j)			-	Active thrust control is the j^{th} thrust phase throttling (THRUST(3, j)).
H(4,j)			deg	Active thrust control is the j^{th} thrust phase cone angle (THRUST(4, j)).
H(5,j)			deg	Active thrust control is the j^{th} thrust phase clock angle (THRUST(5, j)).
H(6,j)			deg/sec	Active thrust control is the j^{th} thrust phase cone angle rate (THRUST(6, j)).
H(7,j)			deg/sec	Active thrust control is the j^{th} thrust phase clock angle rate (THRUST(7, j)).
H(8,j)-(10,j)				Not used.
NMAX	1	1	--	Maximum number of non-linear guidance iterations allowed.
UWATE	6	1.,...,1.	--	Array of control variable weights that may be used to arbitrarily increase the sensitivity of a given control relative to other controls.

Accumulated Guidance Event Statistical Data:

Variable	Dim	Default	Units	Definition
CCØVG	6x7	0,...,0.	km, km/sec	S/C state vector control error array computed at the current guidance event. This array is read as a (6x6) matrix of standard deviations and correlation coefficients. Only the principal diagonal and the lower triangular submatrix are necessary. The 7^{th} column of this array contains the mean values.
CCØVT	6x1	0,...,0.	km, km/sec	S/C state vector control error array computed at the designated target time. This array is read as a (6x6) matrix of standard deviations, correlation coefficients, and means in the same format as CCØVG. Computed whenever KTER=1.
CNTCØV	6x7	0,...,0.	Mixed	Correlation array for the active thrust control variables used at this guidance event. This array is input as an (nxn) matrix of standard deviations and correlation coefficients where n is the number of low thrust controls. Only the principal diagonal and lower triangular partition need to be input. The $(n+1)^{th}$ column vector contains the control means.
DVMAG	2			Delta-velocity magnitude statistics.

Variable	Dim	Default	Units	Definition
DVMAG(1)		0.	km/sec	One-sigma delta-velocity magnitude.
DVMAG(2)		0.	km/sec	Mean delta-velocity magnitude.
DVMCØV	3x4	0,...,0.	km/sec	Delta-velocity vector correlation array. Input format is the same as CCØVG (See Page 51).
GMSCØV	2			S/C mass statistics evaluated at the current guidance event.
GMSCØV(1)		0.	kg	One-sigma S/C mass.
GMSCØV(2)		0.	kg	Mean S/C mass.
MSAMP	1	0.	--	Number of Monte Carlo cycles executed in a previous SIMSEP run in which statistics on CCØVG, CCØVT, CNTCØV, DVMAG, DVMCØV, GMSCØV, TARCØV, and TMSCØV were computed. MSAMP is used to re-initialize the accumulation of statisicts for the current run.
TARCØV	42	0,...,0.	Mixed	Correlation array describing target error statistics. The format here is the same as CNTCØV (See Page 51) except the dimension of the input matrix is determined by the no. of target variables. This array is input whenever KTER = 1, or at the last guidance event.
TMSCØV	2			S/C mass statistics evaluated at the designated target time. Computed whenever KTER = 1.
TMSCØV(1)			kg	One-sigma s/c mass
TMSCØV(2)			kg	Mean s/c mass

2.5 REFSEP Input Description

Input to the detailed trajectory print mode of MAPSEP is made through the namelist $TRAJ and formatted cards. In addition to the baseline trajectory parameters, $TRAJ contains several variables used only in REFSEP (see page 12-A). Of particular importance is the variable KARDS which must be set equal to the number of formatted cards following the namelist. The other REFSEP variables in $TRAJ are used only when S/C tracking information is desired. The print schedule cards follow directly behind $TRAJ and contain such information as start and stop times and time intervals between specified blocks of trajectory output. The format for these cards is exactly the same as that for measurement schedule cards characteristic of the GODSEP mode (see page 34). A brief summary of the format and an example follow.

Each schedule card contains three time control variables in Columns 1-30 (format 3F10.4) and one print code right justified in Columns 37-40 (format I10). The time control variables are START, STØP, and DELT where

START = start time, referenced to TLNCH, for scheduling current print blocks;

STØP = stop time for current print blocks;

DELT = time interval increment for scheduling.

Internal tests modify START if it is less than TSTART, and STØP if it is greater than TEND. TSTART and TEND are input variables in $TRAJ which define the initial and final trajectory times respectively. An additional

option of specifying DELT=0. aids the user in redefining the range of times which are allowed on subsequent cards. The START and STØP times on a DELT=0. card designate the new scheduling interval for all succeeding cards until another DELT=0. card is encountered. The redefined interval supersedes the nominal (TSTART, TEND) interval.

The print code (klmn) is a four digit number designating the print blocks to be output at the appropriate times. Each digit represents a different type of print block and the value of the digit determines the level of detail to be printed (i.e. the largest value of the specified digit includes the print suggested by the smaller non-zero values). The blocks of print are selected as follows:

n = 0 to 3, Nominal Trajectory Print

kℓm0	current time and the Julian date
kℓm1	body relative S/C states and S/C accelerations
kℓm2	individual perturbing accelerations and planetary ephermerides
kℓm3	integration data, Encke formulation

m = 0 to 2, Primary Body Data

kℓ0n	no primary body data
kℓ1n	osculating conic data
kℓ2n	relevant unit vectors

ℓ = 0 to 1, Target Data

k0mn	no target data
k1mn	B-plane, closest approach parameters, and orbital elements relative to the target body.

k = 0 to 1, Tracking Data

$0\ell mn$ no tracking data

$1\ell mn$ S/C in various topocentric coordinate systems;

S/C rise and set times relative to Earth based tracking stations; target body rise and set times relative to one astronomical observatory.

For the special case when the print code is set to (0000) or when the code is not input on the schedule card at all, the default print code of (0001) is assumed.

Figure 2-5 is an example of one possible schedule card. If this card is encountered by REFSEP the print code 1123 will be scheduled at 100.5, 110.5, 120.5, ... , 190.5 days or a total of ten times. Note that the stop time of 200. days is not a scheduled print time.

	$\underbrace{100.5}$	$\underbrace{200.}$	$\underbrace{10.}$	$\underbrace{1123}$
Columns	1 to 5	11 to 14	21 to 23	37 - 40

Figure 2.5 REFSEP Detailed Print Schedule Card

The code 1123 designates all possible print blocks as previously described to be printed at the ten time points. The fact that tracking data is to be computed necessitates the inclusion of the Earth code in the NB array found in $TRAJ. Control phase change print and primary body change print are not included in this code. To obtain this output the IPRINT flag in $TRAJ must also be set to the appropriate value. However, the termination print at the final time is always output in a REFSEP run.

3.0 OUTPUT AND SAMPLE CASES

The form, type and amount of MAPSEP output depends upon the operating mode and whatever options and submodes have been exercised. Output can be very extensive or it can be quite simple and in summary form. Because of MAPSEP complexity, a general rule of thumb is to output as much as possible unless the user has a very specific purpose in mind.

3.1 Card and Tape Output

All modes are capable of storing reference trajectory data via the $TRAJ namelist on disc (the STM file) for subsequent stacked cases. By transferring the results on tape (or permanent file), a permanent record can be obtained to be used for future runs. However, because of the relatively small amount of card input for $TRAJ, use of permanent STM file is not recommended except for GODSEP where a great deal of additional data is stored.

Available card and tape output is shown in Table 3-1 with the input flag that triggers the output. Certain output in the form of punched cards are automatically output if specific options are exercised. Obviously, more than setting an input flag is required for meaningful output, and the user is referred to Chapter 4 for recommended operating procedures.

3.2 Printout

There are two blocks of printout which are common to all modes: initialization and TRAJ print. Initialization print is displayed on the first page of every run and contains the reference trajectory data, including start and end times, initial state vector, spacecraft characteristics, thrust control parameters, etc.

Mode	Input Control Flag	Output Format	Output Data
TOPSEP	ISTMF	STM File	$TRAJ namelist
GODSEP	ISTMF	STM File	$TRAJ namelist; state transition matrices and trajectory data at specified trajectory times.
	GAINCR	GAIN File	$GØDSEP namelist; event schedule; filter gains at measurement events.
	SUMMARY	SUMMARY File	Navigation summary
	PUNCHE	Cards	Knowledge (P) and control (PG) covariances at selected event types.
	IGREAD=0 (and NGUID≠0)	Cards	Computed variation (VARMAT) and sensitivity (S) matrices for guidance events.
SIMSEP	ISTMF	STM File	$TRAJ namelist
	IPUNCH	Cards	Cumulative statistics for each maneuver (CCØVG, CNTCØV, DVMCØV, GMSCØV, CCØVT, TARCØV, and TMSCØV) and for the total mission (ATHCØV, ADVT, ENDCØV, and AMASS).
	IPUNCH (and INREF=0)	Cards	Reference trajectory (XEND and MEND) and guidance event data (XGREF, MGREF, S, XTREF, MTREF and TARGET).

Table 3-1 Card and Tape Output

TRAJ print is output when the trajectory propagation routine is called (and the related print flag is triggered) by the mode in operation. TRAJ print is used either by itself or in association with mode peculiar print

and displays instantaneous trajectory information at a specified time. Trajectory data includes current mission time, spacecraft mass and thruster power, state and acceleration vectors, etc.

The best illustration of mode related output is by example. Hence, the following sections contain sample printout from TOPSEP, GODSEP and SIMSEP, including all necessary input to make the runs. The mission used for all three sample cases is an SEP slow flyby of the comet Encke in 1981.

3.2.1 TOPSEP

The TOPSEP sample case illustrates the STM targeting procedure for an Encke flyby mission. This run represents one iteration in the later stages of the targeting process in which targeting error only is to be minimized. Convergence has not been attained at the conclusion of this iteration; however, extending the maximum iteration restriction to three (NMAX in $TØPSEP) does allow convergence to occur.

The first page of output is a listing of the $TRAJ namelist input which contains reference trajectory data and MØDE = 1 specifying the TOPSEP mode. All $TRAJ variables which are not listed on this page assume the default values as specified in Section 2.1 (Page 4). Together with the default parameters these variables specify the details of the Encke flyby mission. The initial state is provided in geocentric ecliptic coordinates (ICØØRD = 3, NLP = 3) for the launch date of March 24, 1979, (TLNCH = 2443956.65). The trajectory control policy (THRUST) consists of nine segments with a 64 day initial coast followed by 523 days of continuous thrust. Thrust shutdown occurs at 587 days after launch and the trajectory termination time, TEND, occurs at 593.4987 days. Note that termination or final time is mandatory under the STM targeting procedure; thus,

the trajectory termination flag, ISTØP, must maintain its default value (ISTØP = 1). A summary of the above variables and other pertinent $TRAJ parameters may be found on the second page of the sample case output.

The remaining output pages refer to the TOPSEP mode exclusively. The $TØPSEP namelist on the third page contains control and target information. The TOPSEP submode flag, IMØDE, designates the targeting and optimization option; however, the selection of the STM method of targeting (IASTM = 1) precludes the optimization process. The TOPSEP initialization summary follows on the next page and is self-explanatory. Note that X, Y, Z targeting relative to Encke has been designated with desired target values equal to zero and acceptable target tolerances equal to fifty kilometers. Hence, the trajectory is considered targeted and the iteration process converged when X, Y, and Z each fall below fifty kilometers at the final time. To accomplish this task, four controls have been selected -- the cone and clock angle of the sixth thrust phase and the cone and clock angle of the eighth thrust phase. Corrections to these controls shape the low thrust trajectory from 525 days to the final time; the 525 day trajectory arc from launch remains fixed.

The first operation that TOPSEP performs after initialization is propagation of the reference initial conditions over the fixed 525 day arc. Since the initial state reflects the Earth relative injection process, the parking orbit transfer data and injection data are displayed (analytic discussion in Reference 1, Page 129). Beginning at 525 days, the ϕ and θ partitions of the augmented state transition matrix

(Reference 1, Page 140) are integrated to the final time and printed. The termination print block follows immediately and displays the values of all possible target variables. Included in this list are the values of the X, Y, and Z targets which result in a position error of 82939 kilometers and an initial target error index of 2.75 X 10^6.

Following the zeroth iterate and each subsequent iteration is the iteration summary. The parameters which are listed in the summary are defined below and are discussed in Reference 1, Section 5.3.

F = performance index (mass)

DP2 = optimization scaling

EMAG = quadratic target error

GAMA = control step scale factor

E = target error (desired - actual)

DPSI = desired amount of target error to be removed

G = performance gradient WRT control parameters

DU1 = optimization control correction

DU2 = targeting control correction

DU = control correction for this iteration

C*DU = scaled control correction (GAMA*DU)

UOLD = nominal or previous control parameters

UNEW = control parameters after this iteration

P1 = net cost (Analytic Manual, Page 51) for nominal and each trial step

P2 = EMAG for nominal and each trial step

P1P2 = ØSCALE*P1 + P2

SENSITIVITY MATRIX (printed twice) = change in target parameters WRT control parameters.

Once the sensitivity matrix is computed the control correction (DU) is formulated which reduces the target error. Subsequently, four trial

trajectories are integrated each of which incorporates a scaled control correction in the thrust profile. The scale (GAMA) is computed using a polynomial minimization technique and is summarized after the trial trajectory print. Notice that a scale on the control correction for a fifth trial trajectory has been estimated; however, the trajectory is never integrated since the scale is within one percent of that for the fourth trial trajectory (GTRIAL(3) = .01). The best trial trajectory is, of course, the one which minimizes the error index. Clearly the best trial trajectory is number four which has reduced the error index to 4.03×10^2. The position error for this trial trajectory is 1004 kilometers, a reduction of 98% from the initial trajectory error. The new control vector is printed in the summary for the first iteration. It is formulated as follows:

$$\underline{u}_{new} = \underline{u}_{old} + \gamma \cdot \Delta \underline{u}$$

or

$$\begin{bmatrix} 129.691 \\ 272.200 \\ 157.017 \\ 77.844 \end{bmatrix} = \begin{bmatrix} 130.432 \\ 272.530 \\ 165.000 \\ 77.590 \end{bmatrix} + \begin{bmatrix} -.741 \\ -.330 \\ -7.983 \\ .254 \end{bmatrix}$$

where the units of $\underline{u}$ are in degrees. In terms of the printout in the iteration summary

UNEW = UØLD + C*DU

At the conclusion of each run the best trajectory is integrated once again and printed according to the format requested (MPRINT(1) = 1). For

this Encke flyby mission the fixed 525 day arc is not duplicated since it appears in the very first trajectory printout of the zeroth iterate. The trajectory segment which changes from iteration to iteration is printed, however. This arc includes the sixth, seventh, eighth, and ninth thrust phases. If the iteration process were to continue this trajectory would become the reference for the second iteration.

```
$PSTRAJ
 ENGINE = 21.65, 0.65, 21.65,
 ENGINE(11) = 0.64,
 ICOORD = 3,
 NA = 3,10,
 NLP = 3,
 NTP = 10,
 SCMASS = 1988.0,
 STATE = -5.92110445E3,
 2.16714698E3,
 1.61749472E3,
 -6.9455773,
 -8.52510743,
 -7.33123375,
 TLNCH = 2443956.65476,
 TEND=593.4987,  ISTOP=1,
 THRUST =
 9.,64.,8*0.,
 1.,149.,1.,68.1,224.6,5*0.,
 1.,230.,1.,75.,252.,5*0.,
 1.,470.,1.,85.334,269.,5*0.,
 1.,525.,1.,120.501,268.742,5*0.,
 1.,557.,1.355,130.432,272.53,5*0.,
 1.,577.,1.,150.54,280.,5*0.,
 1.,587.,1.,165.,77.59,5*0.,
 9.,600.,8*0.,
 MODE = 1,
 $
```

TRAJECTORY INITIALIZATION

```
INITIAL EPOCH (REFERENCE DATE)
     JULIAN DATE ....  2443956.6547800004
     CALENDAR DATE ....  1979 MAR    24        3 HR 42 MIN 52.9920 SECS
TRAJECTORY START EPOCH        0.0000000000 DAYS AFTER THE INITIAL EPOCH
     JULIAN DATE ....  2443956.6547800004
     CALENDAR DATE ....  1979 MAR    24        3 HR 42 MIN 52.9920 SECS
TRAJECTORY END EPOCH      593.4987000000 DAYS AFTER THE INITIAL EPOCH
     JULIAN DATE ....  2444550.1534799933
     CALENDAR DATE ....  1980 NOV     6        15 HR 41 MIN   .6714 SECS

INITIAL STATE VECTOR AT        0.0000000000 DAYS AFTER THE REFERENCE EPOCH
                          X                        Y                        Z                        MAGNITUDE
     POSITION    -.59211044500000E+04     .21671469800000E+04     .18174047200000E+04     .65615329303342E+04
     VELOCITY    -.65456773000000E+01     .85261678300000E+01     .73312337560000E+01     .13216885367058E+02
SEPS MASS                              1980.0000000000 KG
EXHAUST VELOCITY                         29.4180000000 KM/SEC
ELECTRIC POWER AT 1 A. U.                21.6500000000 KW
THRUSTER EFFICIENCY                        .6400000000
RADIATION PRESSURE COEFFICIENT           -1.0000000000

LIST OF GRAVITATING BODIES
     SUN
     EARTH
     ENCKE
TARGET PLANET IS ENCKE

INTEGRATION STEP FACTOR      .0500

REFERENCE THRUST CONTROLS
```

THRUST PHASE NUMBER	THRUST PHASE END TIME (DAY)	THRUST PHASE THROTTLING	THRUST PHASE CONE ANGLE (DEG)	THRUST PHASE CLOCK ANGLE (DEG)	THRUST PHASE CONE RATE (DEG/SEC)	THRUST PHASE CLOCK RATE (DEG/SEC)	NUMBER OF THRUSTERS
1	64.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2	140.000000	1.000000	68.100000	224.600000	0.000000	0.000000	0.000000
3	236.000000	1.000000	75.000000	252.000000	0.000000	0.000000	0.000000
4	470.000000	1.000000	85.334000	265.000000	0.000000	0.000000	0.000000
5	525.000000	1.000000	120.501000	268.742000	0.000000	0.000000	0.000000
6	567.000000	1.356000	130.432000	272.530000	0.000000	0.000000	0.000000
7	577.000000	1.000000	150.640000	80.000000	0.000000	0.000000	0.000000
8	587.000000	1.000000	165.000000	77.590000	0.000000	0.000000	0.000000
9	800.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000

```
BODY PARAMETERS AND ORBITAL ELEMENTS HAVE BEEN READ-IN FOR ENCKE  AT JULIAN DATE....2444580.0000000000
     PLANET RADIUS                     .50000000000000E+03 KM
     PLANET SPHERE                     .10000000000000E+04 KM
     PLANET GRAVITATIONAL CONSTANT     .10000000000000E-08 KM**3/SEC**2
     SEMI-MAJOR AXIS     .33160812670GE+09 KM    0.               KM/JC
     ECCENTRICITY        .84700000000000E+00     0.               1.0/JC
     INCLINATION         .11950000000000E+02 DEG 0.               DEG/JC
     ASCENDING NODE      .33426000000000E+03 DEG 0.               DEG/JC
     OMEGA-T             .16020000000000E+03 DEG 0.               DEG/JC
     MEAN ANOMALY        0.                  DEG 0.               DEG/JC
```

```
$TOPSEP
 IASTM = 1,
 MPRINT = -1,0,0,0,
 IMODE = 2,
 NMAX = 1,
 STOL=1.E-4,
 IWATE = 1,
 JWATE = 0,
 W(4,6)=2*1.,  W(4,8)=2*1.,
 ULIMIT(1,1) = 125.,267.,155.,75.,
 ULIMIT(1,2) = 135.,280.,165.,90.,
 UWATE=1.,2.,5.,5.,
 TARTOL(1)=3*50.,
 TARGET=3*0.,
 $
```

TOPSEP - TARGETING AND OPTIMIZATION MODE

TOPSEP SUBCODE DESIGNATION : GENERATE TARGETED AND/OR OPTIMIZED TRAJECTORY

METHOD THE PROJECTED GRADIENT METHOD

REFERENCES ROSEN,J.B., THE GRADIENT PROJECTION METHOD FOR NONLINEAR PROGRAMMING
1. PART I , J. SIAM , VOL. 8, NO. 1, MARCH, 1960.
2. PART II, J. SIAM , VOL. 9, NO. 4, DEC , 1961.

TARGETING AND OPTIMIZATION DATA

NO. OF TARGETS	3	TUF =	.100000E+01	GTRIAL(1) =	.100000E+00
NO. OF CONTROLS	4	TLOW =	.100000E+01	GTRIAL(2) =	.500000E+01
MAX. ITERATIONS	1	DF2 =	.400000E-01	GTRIAL(3) =	.100000E-01
DFMAX =	.100E+04	EPSCN =	0.	GTRIAL(4) =	.100000E-14
FCT =	.200E+00	STOL =	.100000E-03	GTRIAL(5) =	.400000E+01

TARGET PARAMETERS

TARGET		VALUE	TOLERANCE
1	X	0.	.50000000000000E+02
2	Y	0.	.50000000000000E+02
3	Z	0.	.50000000000000E+02

THRUST CONTROL DESIGNATIONS (NON-ZERO VALUE FLAGS CONTROL TO BE USED IN SIM-TARGETING)

THRUST PHASE NUMBER	THRUST PHASE END TIME (DAYS)	THRUST PHASE THROTTLING	THRUST PHASE CONE ANGLE (DEG)	THRUST PHASE CLOCK ANGLE (DEG)	THRUST PHASE CONE RATE (DEG/SEC)	THRUST PHASE CLOCK RATE (DEG/SEC)
1	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
2	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
3	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
4	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
5	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
6	0.00000	0.00000	1.00000	1.00000	0.00000	0.00000
7	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
8	0.00000	0.00000	1.00000	1.00000	0.00000	0.00000
9	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

USER INPUT WEIGHTING

SCALE ON CONTROLS IN WEIGHTING ALGORITHM

1 .10000E+01 2 .20000E+01 3 .50000E+01 4 .50000E+01

BOUNDS ON CONTROLS

MAX	.1350000000000E+03	.2800000000000E+03	.1650000000000E+03	.5000000000000E+02
MIN	.1250000000000E+03	.2670000000000E+03	.1550000000000E+03	.7500000000000E+02

```
INACTV(I) = 1, CONTROL ACTIVE
            0, CONTROL INACTIVE (ON BOUND)
           -1, CONTROL WITHIN TOLERANCE REGION

INACTV(I) =    1    1    0    1

(BLANK COMMON REQUIRED, 002123 OCTAL)
(CORE REQUIRED FOR THIS JOB, 061200 OCTAL)

******************************
*                            *
* CURRENT CP TIME      1.802 *
*                            *
******************************
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* * * * * * * * * * * * * * * * * * * * * * * * * *  REFERENCE TRAJECTORY INTEGRATION  * * * * * * * * * * * * * * * * * * * * * * * * *

***** TUG MULTIPLE-IMPULSE PARKING ORBIT TRANSFER AND INJECTION CONDITIONS *****

LAUNCH CONSTRAINTS

MINIMUM BOOSTER LAUNCH AZIMUTH    35.00000  DEG
MAXIMUM BOOSTER LAUNCH AZIMUTH   120.00000  DEG
LATITUDE OF LAUNCH SITE           28.60000  DEG

INNER PARKING ORBIT

RADIUS            6561.93293603  KM        MAX ALLOWABLE EQ INCLINATION   59.76472  DEG
EQ INCLINATION      59.76472171  DEG       MIN ALLOWABLE EQ INCLINATION   28.60000  DEG

MIN PLANE CHANGE TO OUTER PARKING ORBIT    4.20728  DEG
EQ INCLINATION OF OUTER PARKING ORBIT     63.97200  DEG

TUG CHARACTERISTICS AND REQUIREMENTS

DRY WEIGHT         1714.60000  KG     FIRST IMPULSE, DELVA  0.               KM/SEC     FUEL FOR DELVA  0.              KG
MAX FUEL WEIGHT   10673.00000  KG     SECOND IMPULSE,DELVB   .575691093E+00  KM/SEC     FUEL FOR DELVB   .248559318E+04  KG
SEP S/C WEIGHT ,   1988.00000  KG     THIRD IMPULSE, DELVD   .548199665E+01  KM/SEC     FUEL FOR DELVD   .993994328E+04  KG
TOTAL WEIGHT      14375.60000  KG     TOTAL VEL INCREMENT    .605768774E+01  KM/SEC     TOTAL FUEL       .124259365E+05  KG
SPECIFIC IMPULSE    309.20000  SEC

THE FUEL REQUIRED FOR INJECTION IS GREATER THAN THE TUGS FUEL CAPACITY

SINGLE IMPULSE INJECTION FROM THE INNER PARKING ORBIT

IMPULSE, DELV1    .537914491E+01  KM/SEC
FUEL FOR DELV1    .119337277E+05  KG

INJECTION PARAMETERS

RADIUS, PRC    .656193293602342E+04  KM      INJECTION IMPULSE, DELVD     .548199665160033E+01  KM/SEC
INC, PINC      .405704242355696E+02  DEG     IN-PLANE ANGLE, CHI          .749759792286642E+02  DEG
TIME, PTC     0.                     SEC   , OUT-OF-PLANE ANGLE, PSI     0.                     DEG
```

JULIAN DATE -- 2443956.65476000 CONTROL PHASE -- 1 PRIMARY BODY -- EARTH
DAYS FROM LAUNCH -- 0.00000000 PRESENT S/C MASS -- 1988.00000000 KG EPHEMERIS BODY -- ENCKE
DAYS FROM CUTOFF -- 593.49870000 POWER AVAILABLE -- 21.00000000 KW TARGET BODY -- ENCKE

S/C RELATIVE STATES		X	Y	Z	MAGNITUDE
SUN	POSITION	-.14895007432016E+09	-.75900043971998E+07	.18174047200000E+04	.14914332975374E+09
	VELOCITY	-.59152528347334E+01	-.38384877901900E+02	-.73312337500000E+01	.39523866915317E+02
EARTH	POSITION	-.59211044500000E+04	.21871469800000E+04	.18174047200000E+04	.65619329360342E+04
	VELOCITY	-.69456773000000E+01	-.85261078300000E+01	-.73312337500000E+01	.13216805067098E+02
ENCKE	POSITION	-.72117697876976E+09	.21027195070929E+09	-.11195358181826E+08	.75128546813586E+09
	VELOCITY	-.63857481549963E+01	-.43475374859220E+02	-.85287839554858E+01	.45093676941330E+02
S/C ACCELERATIONS		X	Y	Z	MAGNITUDE
PRIMARY BODY		.84558093249666E-02	-.30948587036085E-02	-.25953986666108E-02	.93709635050137E-02
PERTURBING BODIES		-.45869877252119E-09	-.12214915425694E-09	-.72702940115380E-10	.48021942615968E-09
THRUST		0.	0.	0.	0.
RADIATION PRESSURE		0.	0.	0.	0.

**** PRIMARY BODY CHANGE ****

JULIAN DATE -- 2443960.22669455 CONTROL PHASE -- 1 PRIMARY BODY -- SUN
DAYS FROM LAUNCH -- 3.57191456 PRESENT S/C MASS -- 1988.00000000 KG EPHEMERIS BODY -- ENCKE
DAYS FROM CUTOFF -- 589.92678544 POWER AVAILABLE -- 21.00000000 KW TARGET BODY -- ENCKE

S/C RELATIVE STATES		X	Y	Z	MAGNITUDE
SUN	POSITION	-.14843440457390E+09	-.18499642910694E+08	-.14647351036397E+07	.14958959920488E+09
	VELOCITY	.26062793254572E+01	-.35178178377871E+02	-.46775960084194E+01	.35583378275196E+02
EARTH	POSITION	-.91491215632439E+05	-.17125875244262E+07	-.14647351036397E+07	.22553381251777E+07
	VELOCITY	-.25732762252854E+00	-.54697083948675E+01	-.46775960084194E+01	.72016551369845E+01
ENCKE	POSITION	-.72140798786383E+09	.19778533747162E+09	-.13031219322321E+08	.74814325991051E+09
	VELOCITY	.22785416285257E+00	-.40307371795633E+02	-.58731172406424E+01	.40733699329466E+02
S/C ACCELERATIONS		X	Y	Z	MAGNITUDE
PRIMARY BODY		.58849002436480E-05	.73344554710939E-06	.58071577091805E-07	.59307137476301E-05
PERTURBING BODIES		.32358216233779E-08	.60235345714513E-07	.51516107760791E-07	.79326393928756E-07
THRUST		0.	0.	0.	0.
RADIATION PRESSURE		0.	0.	0.	0.

**** CONTROL PHASE CHANGE ****

JULIAN DATE	-- 2444026.65478000	CONTROL PHASE	-- 2	PRIMARY BODY	-- SUN
DAYS FROM LAUNCH-	64.00000000	PRESENT S/C MASS--	1988.00000000 KG	EPHEMERIS BODY	-- ENCKE
DAYS FROM CUTOFF-	529.49870000	POWER AVAILABLE--	15.13509631 KW	TARGET BODY	-- ENCKE

THRUST PHASE DURATION (DAYS)	THRUST PHASE THROTTLING	THRUST PHASE CONE ANGLE (DEG)	THRUST PHASE CLOCK ANGLE (DEG)	THRUST PHASE CONE RATE (DEG/SEC)	THRUST PHASE CLOCK RATE (DEG/SEC)
76.00000000	1.00000000	68.10000000	224.60000000	0.00000000	0.00000000

S/C RELATIVE STATES		X	Y	Z	MAGNITUDE
SUN	POSITION	-.72133655646799E+08	-.16519452505711E+09	-.21882658822634E+08	.18521530870816E+09
	VELOCITY	.22518307777927E+02	-.20211559127555E+02	-.28178336655736E+01	.30389762478872E+02
EARTH	POSITION	-.87367504859284E+07	-.31504483798014E+08	-.21882658822630E+08	.39345597262146E+08
	VELOCITY	-.40564008885459E+01	-.76497387616778E+01	-.28178336655736E+01	.91056618573808E+01
ENCKE	POSITION	-.65290831955255E+09	.18681438872440E+08	-.35583692665012E+08	.65437365273756E+09
	VELOCITY	.21893468945360E+02	-.25951847275191E+02	-.39691124219978E+01	.34184444018834E+02

S/C ACCELERATIONS	X	Y	Z	MAGNITUDE
PRIMARY BODY	.15060468130011E-05	.35340160699750E-05	.45706848421639E-06	.38868377688276E-05
PERTURBING BODIES	.65240429166330E-10	.22473266591271E-09	.14501462924943E-09	.27533043120833E-09
THRUST	-.25676855761707E-06	-.52047741417237E-07	.26271267531807E-06	.33125743598539E-06
RADIATION PRESSURE	0.	0.	0.	0.

**** CONTROL PHASE CHANGE ****

JULIAN DATE	-- 2444096.65478000	CONTROL PHASE	-- 3	PRIMARY BODY	-- SUN
DAYS FROM LAUNCH-	140.00000000	PRESENT S/C MASS-	1876.64497148 KG	EPHEMERIS BODY	-- ENCKE
DAYS FROM CUTOFF-	453.49870000	POWER AVAILABLE--	8.59838522 KW	TARGET BODY	-- ENCKE

THRUST PHASE DURATION (DAYS)	THRUST PHASE THROTTLING	THRUST PHASE CONE ANGLE (DEG)	THRUST PHASE CLOCK ANGLE (DEG)	THRUST PHASE CONE RATE (DEG/SEC)	THRUST PHASE CLOCK RATE (DEG/SEC)
90.00000000	1.00000000	75.00000000	252.00000000	0.00000000	0.00000000

S/C RELATIVE STATES		X	Y	Z	MAGNITUDE
SUN	POSITION	.81505675986866E+08	-.23913574328411E+09	-.28367385253284E+08	.25407150251064E+09
	VELOCITY	.22050188504456E+02	-.30000090315889E+01	.45083719590774E+00	.22258746335415E+02
EARTH	POSITION	-.31505475458463E+08	-.13749312757250E+09	-.28367385253284E+08	.14388072720014E+09
	VELOCITY	.25669998877772E+01	-.24595963081069E+02	.45083719590774E+00	.25132222254267E+02
ENCKE	POSITION	-.49647305169269E+09	-.91184590810056E+08	-.52369783737429E+08	.50759052557181E+09
	VELOCITY	.23712446713307E+02	-.94021125767844E+01	-.57595073358497E+00	.25514928361363E+02

S/C ACCELERATIONS	X	Y	Z	MAGNITUDE
PRIMARY BODY	-.65547664787487E-06	.19350241994651E-05	.22954149874820E-06	.20558637151607E-05
PERTURBING BODIES	-.87557175391244E-11	.30391702171747E-10	.38429015264374E-11	.31860415551795E-10
THRUST	-.15485879867584E-06	-.11360232027376E-06	.53366937812215E-07	.19933580901695E-06
RADIATION PRESSURE	0.	0.	0.	0.

**** CONTROL PHASE CHANGE ****

JULIAN DATE --	2444186.65478000	CONTROL PHASE --	4	PRIMARY BODY --	SUN
DAYS FROM LAUNCH-	235.00000000	PRESENT S/C MASS-	1796.13915434 KG	EPHEMERIS BODY --	ENCKE
DAYS FROM CUTOFF-	363.49870000	POWER AVAILABLE--	5.62680653 KW	TARGET BODY --	ENCKE

THRUST PHASE DURATION (DAYS)	THRUST PHASE THROTTLING	THRUST PHASE CONE ANGLE (DEG)	THRUST PHASE CLOCK ANGLE (DEG)	THRUST PHASE CONE RATE (DEG/SEC)	THRUST PHASE CLOCK RATE (DEG/SEC)
240.00000000	1.00000000	85.33400000	269.00000000	0.00000000	0.00000000

S/C RELATIVE STATES		X	Y	Z	MAGNITUDE
SUN	POSITION	.22436751756627E+09	-.22001273741855E+09	-.18091599694180E+08	.31475976238743E+09
	VELOCITY	.14585454185548E+02	.66461433108371E+01	.19392027975748E+01	.16148804977863E+02
EARTH	POSITION	.12170208217577E+09	-.32687320387389E+09	-.18091599694180E+08	.34926323692965E+09
	VELOCITY	.36556831205848E+02	-.13883328442811E+02	.19392027975748E+01	.39152388758395E+02
ENCKE	POSITION	-.32883743836082E+09	-.12443634587265E+09	-.50838246936660E+08	.35525060505710E+09
	VELOCITY	.19237440467474E+02	-.39574057123381E+00	.10256107100954E+01	.19268816454362E+02

S/C ACCELERATIONS	X	Y	Z	MAGNITUDE
PRIMARY BODY	-.95484786590655E-06	.93631509567494E-06	.76994689595545E-07	.13395329765555E-05
PERTURBING BODIES	-.13883045568535E-10	-.10154834105748E-10	.17134670970042E-12	.17201423478285E-10
THRUST	-.67005778934094E-07	-.10471559899898E-06	.17278253975345E-08	.13615560077444E-06
RADIATION PRESSURE	0.	0.	0.	0.

**** CONTROL PHASE CHANGE ****

JULIAN DATE --	2444426.65478000	CONTROL PHASE --	5	PRIMARY BODY --	SUN
DAYS FROM LAUNCH-	475.00000000	PRESENT S/C MASS-	1639.30654634 KG	EPHEMERIS BODY --	ENCKE
DAYS FROM CUTOFF-	123.49870000	POWER AVAILABLE--	6.49525979 KW	TARGET BODY --	ENCKE

THRUST PHASE DURATION (DAYS)	THRUST PHASE THROTTLING	THRUST PHASE CONE ANGLE (DEG)	THRUST PHASE CLOCK ANGLE (DEG)	THRUST PHASE CONE RATE (DEG/SEC)	THRUST PHASE CLOCK RATE (DEG/SEC)
55.00000000	1.00000000	120.50100000	268.74200000	0.00000000	0.00000000

S/C RELATIVE STATES		X	Y	Z	MAGNITUDE
SUN	POSITION	.29181529237133E+09	.14368615066798E+08	.25332247271527E+08	.29326457355213E+09
	VELOCITY	-.94942254490297E+01	.12606135101767E+02	.16078934365953E+01	.15863173717275E+02
EARTH	POSITION	.25442042180903E+09	-.16179775862760E+09	.25332247271527E+08	.30257228530556E+09
	VELOCITY	-.37882773745280E+02	.53908510199149E+01	.16078934365953E+01	.38298192828485E+02
ENCKE	POSITION	-.52878402123880E+08	-.43772643688644E+08	-.17497660741223E+08	.70643227823481E+08
	VELOCITY	.79300717875675E+01	.55329692118303E+01	.18651458056417E+01	.98477690738227E+01

S/C ACCELERATIONS	X	Y	Z	MAGNITUDE
PRIMARY BODY	-.15354627581650E-05	-.75604239730527E-07	-.13329226837283E-06	.15430903621635E-05
PERTURBING BODIES	-.79944209713267E-11	.14549995403448E-10	-.36900657433706E-12	.16605709866206E-10
THRUST	-.86046795234526E-07	-.16262745176468E-06	-.43094037177803E-08	.17236837045185E-06
RADIATION PRESSURE	0.	0.	0.	0.

JULIAN DATE --	2444481.65478000	CONTROL PHASE --	6	PRIMARY BODY --	SUN
DAYS FROM LAUNCH-	525.00000000	PRESENT S/C MASS-	1584.46949691 KG	EPHEMERIS BODY --	ENCKE
DAYS FROM CUTOFF-	68.49870000	POWER AVAILABLE--	9.64559458 KW	TARGET BODY --	ENCKE

S/C RELATIVE STATES		X	Y	Z	MAGNITUDE
SUN	POSITION	.22655254008362E+09	.69717242681515E+08	.30928878636764E+08	.23904631949154E+09
	VELOCITY	-.18476439527010E+02	.10145832930359E+02	.61272696176943E+00	.21047725566658E+02
EARTH	POSITION	.87601281688083E+08	.12889648027078E+09	.30928878636764E+08	.15888637848599E+09
	VELOCITY	-.29662980772823E+02	-.17152234813416E+02	.61272696176943E+00	.34270497833285E+02
ENCKE	POSITION	-.21595665050104E+08	-.18901200356085E+08	-.88068716861246E+07	.29955132999939E+08
	VELOCITY	.53086276615312E+01	.47303670375554E+01	.17717682953790E+01	.73278280086473E+01

S/C ACCELERATIONS	X	Y	Z	MAGNITUDE
PRIMARY BODY	-.22010736701162E-05	-.67733862925840E-06	-.30048985718046E-06	.23024571199987E-05
PERTURBING BODIES	-.25087919230339E-10	-.60349863633136E-11	-.31113724171858E-11	.25990466529341E-10
THRUST	-.13683762714169E-06	-.32827990522234E-06	-.42074401976915E-07	.35690644767799E-06
RADIATION PRESSURE	0.	0.	0.	0.

**** CONTROL PHASE CHANGE ****

JULIAN DATE --	2444523.65478000	CONTROL PHASE --	7	PRIMARY BODY --	SUN
DAYS FROM LAUNCH-	567.00000000	PRESENT S/C MASS-	1493.44201936 KG	EPHEMERIS BODY --	ENCKE
DAYS FROM CUTOFF-	26.49870000	POWER AVAILABLE--	16.67987938 KW	TARGET BODY --	ENCKE

THRUST PHASE DURATION (DAYS)	THRUST PHASE THROTTLING	THRUST PHASE CONE ANGLE (DEG)	THRUST PHASE CLOCK ANGLE (DEG)	THRUST PHASE CONE RATE (DEG/SEC)	THRUST PHASE CLOCK RATE (DEG/SEC)
10.00000000	1.00000000	150.64000000	80.00000000	0.00000000	0.00000000

S/C RELATIVE STATES		X	Y	Z	MAGNITUDE
SUN	POSITION	.14192862946350E+09	.96881915478519E+08	.30142694473465E+08	.17446610971273E+09
	VELOCITY	-.28917984206636E+02	.36395563126574E+01	-.13388624412309E+01	.29176394031010E+02
EARTH	POSITION	-.92536043278694E+09	.50761880848011E+08	.30142694473465E+08	.59036930388643E+08
	VELOCITY	-.19231323058449E+02	-.24588147319041E+02	-.13388624412309E+01	.31244412745987E+02
ENCKE	POSITION	-.59190528364353E+07	-.51135300011473E+07	-.29111871765473E+07	.83461606842995E+07
	VELOCITY	.34015396112220E+01	.25891954654756E+01	.14388472108106E+01	.45105084171531E+01

S/C ACCELERATIONS	X	Y	Z	MAGNITUDE
PRIMARY BODY	-.35468972255120E-05	-.24211473579903E-05	-.75328733745636E-06	.43600319599021E-05
PERTURBING BODIES	-.17930453584863E-10	-.10513323940978E-09	-.59109677491719E-10	.12180715103594E-09
THRUST	-.47693758171761E-06	-.37366768984846E-07	-.11392785417752E-06	.48596094210943E-06
RADIATION PRESSURE	0.	0.	0.	0.

**** CONTROL PHASE CHANGE ****

JULIAN DATE	-- 2444533.65478000	CONTROL PHASE --	8	PRIMARY BODY	-- SUN
DAYS FROM LAUNCH-	577.00000000	PRESENT S/C MASS-	1470.09472298 KG	EPHEMERIS BODY	-- ENCKE
DAYS FROM CUTOFF-	16.49870000	POWER AVAILABLE--	20.93123003 KW	TARGET BODY	-- ENCKE

THRUST PHASE DURATION (DAYS)	THRUST PHASE THROTTLING	THRUST PHASE CONE ANGLE (DEG)	THRUST PHASE CLOCK ANGLE (DEG)	THRUST PHASE CONE RATE (DEG/SEC)	THRUST PHASE CLOCK RATE (DEG/SEC)
10.00000000	1.00000000	165.00000000	77.59000000	0.00000000	0.00000000

S/C RELATIVE STATES		X	Y	Z	MAGNITUDE
SUN	POSITION	.11536375373972E+09	.98975718669575E+08	.28628610954429E+08	.15467574448573E+09
	VELOCITY	-.32673294633626E+02	.10397080044939E+01	-.22096446616590E+01	.32764427424893E+02
EARTH	POSITION	-.16215553531870E+08	.29277203537446E+08	.28628610954429E+08	.44041982113635E+08
	VELOCITY	-.16243384452548E+02	-.25175425600348E+02	-.22096446616590E+01	.31168985546095E+02
ENCKE	POSITION	-.32708948139119E+07	-.29738995923824E+07	.17264099423141E+07	.47519435934078E+07
	VELOCITY	.27660873168007E+01	.23526184835128E+01	.12994753543935E+01	.38139628635058E+01

S/C ACCELERATIONS	X	Y	Z	MAGNITUDE
PRIMARY BODY	-.41372766370882E-05	-.35495544770265E-05	-.10267044835862E-05	.55471179052380E-05
PERTURBING BODIES	.66508578915358E-10	-.14580465982332E-09	-.13522205438277E-09	.20856150234326E-09
THRUST	-.52306840803194E-06	-.24873380063079E-06	-.13840057194671E-06	.59286952310842E-06
RADIATION PRESSURE	0.	0.	0.	0.

**** CONTROL PHASE CHANGE ****

JULIAN DATE	-- 2444543.65478000	CONTROL PHASE --	9	PRIMARY BODY	-- SUN
DAYS FROM LAUNCH-	587.00000000	PRESENT S/C MASS-	1443.41152698 KG	EPHEMERIS BODY	-- ENCKE
DAYS FROM CUTOFF-	6.49870000	POWER AVAILABLE--	21.00000000 KW	TARGET BODY	-- ENCKE

THRUST PHASE DURATION (DAYS)	THRUST PHASE THROTTLING	THRUST PHASE CONE ANGLE (DEG)	THRUST PHASE CLOCK ANGLE (DEG)	THRUST PHASE CONE RATE (DEG/SEC)	THRUST PHASE CLOCK RATE (DEG/SEC)
213.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000

S/C RELATIVE STATES		X	Y	Z	MAGNITUDE
SUN	POSITION	.85306527454849E+08	.96229802945169E+08	.26231742403221E+08	.13271926055611E+09
	VELOCITY	-.37002835974564E+02	-.34685730437012E+01	-.34068842090020E+01	.37285830642765E+02
EARTH	POSITION	-.31892436310481E+08	.70402766691464E+07	.26231742403221E+08	.41890305772557E+08
	VELOCITY	-.18223904850107E+02	-.26470403126967E+02	-.34068842090020E+01	.32317175150428E+02
ENCKE	POSITION	-.12169357342672E+07	-.11202908821149E+07	-.66923435558736E+06	.17843370938768E+07
	VELOCITY	.20698595921776E+01	.19325803697624E+01	.11470715578487E+01	.30685009693122E+01

S/C ACCELERATIONS	X	Y	Z	MAGNITUDE
PRIMARY BODY	-.48427520167210E-05	-.55763912857267E-05	-.14891454055792E-05	.75343175424588E-05
PERTURBING BODIES	.16062135274286E-09	-.45882240359812E-10	-.14399072705947E-09	.22140638278813E-09
THRUST	0.	0.	0.	0.
RADIATION PRESSURE	0.	0.	0.	0.

JULIAN DATE -- 2444550.15347999
DAYS FROM LAUNCH- 593.498 0000
DAYS FROM CUTOFF- 0.0000000

CONTROL PHASE -- 9
PRESENT S/C MASS- 1443.41152698 KG
POWER AVAILABLE-- 21.00000000 KW

PRIMARY BODY -- SUN
EPHEMERIS BODY -- ENCKE
TARGET BODY -- ENCKE

S/C RELATIVE STATES		X	Y	Z	MAGNITUDE
SUN	POSITION	.6374351277F080E+08	.9552159018912E+08	.2400983937708E+08	.1173311941192EE+09
	VELOCITY	-.3984130340626E+02	-.6788382541266SE+01	-.4370772365833SE+01	.4065114076764 2E+02
EARTH	POSITION	-.4218413976302 3E+08	-.8196899533666 6E+07	.2406098393770 8E+08	.4925060159993 9E+08
	VELOCITY	-.1851448094734 8E+02	-.2796433529843 9E+02	-.4370772365833 5E+01	.3382149766800 9E+02
ENCKE	POSITION	-.5669634853965 9E+05	-.5384025658174 5E+05	-.2767070353159 4E+05	.8293926279717 4E+05
	VELOCITY	.2053545146092 1E+01	.1879096289710 6E+01	.1139911133835 9E+01	.3007897592353 5E+01

S/C ACCELERATIONS	X	Y	Z	MAGNITUDE
PRIMARY BODY	-.52372987505530E-05	-.78482807498313E-05	-.19769001679701E-05	.96401734011809E-05
PERTURBING BODIES	.12936480541058E-05	.14841721014430E-10	-.81269312375553E-10	.15349342232733E-05
THRUST	0.	0.	0.	0.
RADIATION PRESSURE	0.	0.	0.	0.

PHI

.1428F68734 76E+01	.398013674148E+00	.134351397239E+00	.678350275883E+07	.115163342709E+07	.350992959778E+06
.480172874465E+00	.973666187801E+00	.105000040440E+00	.127261772827E+07	.599426864069E+07	.226526644654E+06
.148809547322E+00	.516786986810E-01	.681787457901E+00	.382466073950E+06	.217047249637E+06	.507811705885E+07
.180459203806E-06	.221056958752E-06	.680449032884E-07	.146163519223E+01	.918513890308E+00	.260789520000E+00
.299999089453E-06	.675292181306E-07	.692029741875E-07	.104880928139E+01	.132762433087E+01	.264992619588E+00
.629948365643E-07	.540885607663E-07	.135094728534E-06	.292438728063E+00	.251028685652E+00	.422414766058E+00

THETA

-.676408997001E+07	.522739734722E+06	.224940512570E+06	-.397088980217E+05
.998397397661E+06	.485252449814E+06	-.471707404148E+06	.341055826158E+04
-.734850766195E+06	-.462334578766E+07	.778298529528E+05	.136166097548E+06
-.175356638458E+01	.690324977617E-01	.219467930448E+00	-.386313971451E-01
-.368675865991E+00	.446734976172E-01	.474506490436E+00	.328364594026E-02
-.283546611876E+00	-.853828580387E+00	.742152867018E-01	.132753304901E+00

++ TERMINATION DATA +++

REQUESTED STOPPING CONDITION : TEND
ACTUAL STOPPING CONDITION : TEND

FLIGHT TIME .593498700000CCE+03
FINAL S/C MASS .144341152697 66E+04

X =	-.56696348589659E+05	VX =	.20535451460921E+01	EDT =	.14462134434886E+04	RCA =	.42713789258384E+04
Y =	-.53840296581745E+05	VY =	.18790962897106E+01	BDR =	.40190974862484E+04	VCA =	.30078975923535E+01
Z =	-.27670703531504E+05	VZ =	.11399111338359E+01	VHP =	.30078975923534E+01	ICA =	.71740169444740E+02
R =	.82939262797174E+05	V =	.30078975923535E+01	TSOI =	.59381741806975E+03	TRCA =	.59381741806975E+03

CONIC ELEMENTS	A	E	INC	NODE	APS	MA	TA
S/C TARGET CENT	-.110528E-09	.286451E+14	.717402E+02	230225E+03	.664801E+02	-.749393E+15	.272952E+03

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SUMMARY FOR ITERATION NUMBER  0

F     =   -.144341152698E+04              DF2  =    .400000000000E-01
EMAG  =    .275156852534E+07              GAMA =   0.
E     =   -.566563485897E+05   -.532402965817E+05   -.276707035315E+05
DPSI  =   0.                   0.                   0.
G     =   0.                   0.                   0.                   0.
CU1   =   0.                   0.                   0.                   0.
CU2   =   0.                   0.                   0.                   0.
CU    =   0.                   0.                   0.                   0.
C*CU  =   0.                   0.                   0.                   0.
UOLD  =    .170432300000E+03    .272530000000E+03    .165000000000E+03    .775900000000E+02
UNEW  =    .170422966056E+03    .272530000000E+03    .165000000000E+03    .775900000000E+02
P1    =   0.                   0.                   0.                   0.                   0.                   0.
P2    =   0.                   0.                   0.                   0.                   0.                   0.
P1P2  =   0.                   0.                   0.                   0.                   0.                   0.

SENSITIVITY MATRIX

    -.110556408078E+06    .912352950190E+04    .392595256546E+04   -.693051012817E+03
     .174252218325E+05    .759658832662E+04   -.823284730842E+04    .595254739957E+02
    -.122555665435E+05   -.806926064529E+05    .135838719037E+04    .237654673180E+04

   -.1E+06    .9E+04    .4E+04   -.7E+03
    .2E+05    .8E+04   -.6E+04    .6E+02
   -.1E+05   -.8E+05    .1E+04    .2E+04
*****************************************************************************************************
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WEIGHTED SENSITIVITY MATRIX

-.67641E+07	.10455E+07	.11247E+07	-.19854E+06
.99840E+06	.47859E+06	.23585E+07	.17053E+05
-.73485E+06	-.92467E+07	.38915E+06	.68083E+06

CONTROL VECTOR INNER PRODUCTS

1	0.00000	.00922	.56412	.17623
2	.00922	0.00000	.18127	.97658
3	.56412	.18127	0.00000	.00076
4	.17623	.97658	.00076	0.00000

THE FOLLOWING CONTROLS ARE LINEARLY DEPENDENT

0

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* * * * * * * * * * * * * * * * * * * * * * * * * * * TRIAL TRAJ. INTEG. NO.  1 * * * * * * * * * * * * * * * * * * * * * * * * * * * *

U

     .129432000000E+03    .272530000000E+03    .165000000000E+03    .775900000000E+02

DELTA U

     .158632165645E+00    -.705262493252E-01    -.170837573396E+01    .543998183890E-01

******************************************************* TERMINATION DATA *******************************************************

REQUESTED STOPPING CONDITION ; TEND
ACTUAL STOPPING CONDITION    ; TEND

FLIGHT TIME       .593549700000000E+03
FINAL S/C MASS    .144341483841 98E+04

X =  -.452559347386 3FE+05    VX =   .205184186416 20E+01    BDT  =   .877282663EE689E+03    RCA  =   .326891103997 82E+04
Y =  -.430130084357 26E+05    VY =   .189434210146 47E+01    BDR  =  -.314899261912 77E+04    VCA  =   .301620817360 31E+01
Z =  -.220892153291 70E+05    VZ =   .113970378327 02E+01    VHP  =   .301620817360 30E+01    ICA  =   .756126977468 14E+02
R =   .662553656382 03E+05    V  =   .301620817360 31E+01    TSOI =   .593752631626 16E+03    TRCA =   .593752631F261 6E+03

CONIC ELEMENTS         A              E             INC           NODE          APS           MA             TA
S/C TARGET CENT    -.105920E-09    .297390E+14    .756127E+02    .228724E+03    .670397E+02    -.602025E+15    .272828E+03
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TRIAL TRAJ. INTEG. NO. 2

U

.120432000000E+03 .272530000000E+03 .165000000000E+03 .775900000000E+02

DELTA U

-.793166628227E+00 -.252671246626E+00 -.854187866988E+01 .271999091945E+00

TERMINATION DATA

REQUESTED STOPPING CONDITION ; TEND
ACTUAL STOPPING CONDITION ; TEND

FLIGHT TIME .593494700000E+03
FINAL S/C MASS .144342820868E+04

X =	.459500266098698E+04	VX =	.204935895524617E+01	BDT =	.105399995362295E+04	RCA =	.105787551691488E+04
Y =	.293210289963E+04	VY =	.195782279384419E+01	BDR =	.904693707880953E+02	VCA =	.305509973015907E+01
Z =	.205442866671096E+04	VZ =	.114047039239210E+01	VHP =	.305509973019048E+01	ICA =	.224351912265e0E+02
R =	.582511306619688E+04	V =	.305509973019058E+01	TSOI =	.593476998848095E+03	TPCA =	.593476998848095E+03

CONIC ELEMENTS	A	E	INC	NODE	APS	MA	TA
S/C TARGET CENT	-.107139E-09	.987362E+13	.224352E+02	326641E+03	.348001E+03	.534654E+14	.795367E+02

* TRIAL TRAJ. INTEG. NO. 3 *

U

.130432000000E+03 .272530000000E+03 .165000000000E+03 .775900000000E+02

DELTA U

-.767225797102E+00 -.241100795258E+00 -.826257353870E+01 .263105177036E+00

TERMINATION DATA

REQUESTED STOPPING CONDITION ; TEND
ACTUAL STOPPING CONDITION ; TEND

FLIGHT TIME .593498700000E+03
FINAL S/C MASS .14474276583163E+04

X =	.24187139234333E+04	VX =	.20493220985402E+01	BDT =	.96190904681560E+03	RCA =	.96241139620268E+03
Y =	.57711760711670E+03	VY =	.19951613183518E+01	BDR =	-.31091187610313E+02	VCA =	.30533361773328E+01
Z =	.10099647264481E+04	VZ =	.11403880775700E+01	VHP =	.30533361773325E+01	ICA =	.22005125180658E+02
R =	.27976606794255E+04	V =	.30533361773326E+01	TSOI =	.59348977186099E+03	TRCA =	.59348874234092E+03

CONIC ELEMENTS	A	E	INC	NODE	APS	MA	TA
S/C TARGET CENT	-.107263E-09	.857243E+13	.220051E+02	.338707E+03	.458742E+01	.244903E+14	.698785E+02

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* * * * * * * * * * * * * * * * * * * * * * * * * TRIAL TRAJ. INTEG. NO.  4 * * * * * * * * * * * * * * * * * * * * * * * * * * *

U

        .130432000000E+03    .272530000000E+03    .165000000000E+03    .775900000000E+02

DELTA U

        -.741286595856E+00   -.229565822375E+00   -.798315888170E+01    .254207774455E+00

****************************************************** TERMINATION DATA ******************************************************

REQUESTED STOPPING CONDITION : TEND
ACTUAL STOPPING CONDITION    : TEND

FLIGHT TIME       .593498700000000E+03
FINAL S/C MASS    .144342717608088E+04

X =   .259411229F10446E+03    VX =   .204529717728C1E+01    BDT  =   .877500900671 92E+03    RCA  =   .850883332489588E+03
Y =  -.970578168869 22E+03    VY =   .195249933063 43E+01    BDR  =  -.153833503821 42E+03    VCA  =   .305159865318392E+01
Z =  -.299577400584 36E+02    VZ =   .114031035 82541E+01    VHP  =   .305158653183 88E+01    ICA  =   .239887229125 94E+02
R =   .100356200574 15E+04    V  =   .305158653183 91E+01    TSOI =   .593498729542 12E+03    TRCA =   .593500452358 31E+03

CONIC ELEMENTS            A             E             INC           NODE          APS           MA            TA
S/C TARGET CENT      -.107386E-09   .829656E+13   .239887E+02   .288481F+03   .232010E+02   -.430243E+13   .332588E+03
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SELECTION OF THE NEXT TRIAL TRAJECTORY

I, TRIAL TRAJECTORY NUMBER

X(I), SCALE (GAMMA) ON CONTROL CORRECTION (DU)
X(1) NOMINAL FIRST STEP SCALE FACTOR
X(2) QUADRATIC EXTREMUM ESTIMATION (TWO POINTS, ONE SLOPE)
X(3) CUBIC EXTREMUM ESTIMATION (THREE POINTS, ONE SLOPE)
X(4) CUBIC EXTREMUM ESTIMATION (FOUR POINTS)
X(5) QUADRATIC EXTREMUM ESTIMATION (THREE POINTS)

Y(I), QUADRATIC ERROR INDEX (EMAG)

DYDX1, EXPECTED CHANGE IN QUADRATIC ERROR INDEX WRT CHANGE IN SCALE FACTOR

I	X(I)	Y(I)	PREDICTED MIN
0	0.	.27515685253355E+07	
1	.10000000000000E+01	.17559096129588E+07	
2	.50000000000000E+01	.13572776893591E+05	-.13353682012077E+06
3	.48265383713006E+01	.71307621332626E+04	.10251963073805E+05
4	.46729526315126E+01	.40285467974712E+03	-.35172937864065E+03
5	.46965085275953E+01	0.	.32373545393348E+03

DYDX1= -.11006274100E+07 MIN=-4 Y(MIN)= .40285467974712E+03

INACTV(I) = 1 1 1 1

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******************************
*                            *
* CURRENT CP TIME    19.756  *
*                            *
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THE MAXIMUM NO. OF ITERATIONS HAS BEEN REACHED

SUMMARY FOR ITERATION NUMBER  1

F     =   -.144342710806E+04                DF2   =   .400000000000E-01
EMAG  =    .402854679747E+03                GAMA  =   .467295263151E+01
E     =    .253411229610E+03   -.970578168865E+03   -.299577430684E+02
DPSI  =   -.113392697179E+05   -.167605921636E+05   -.553414070630E+04
G     =   0.                   0.                   0.                   0.
CU1   =   0.                   0.                   0.                   0.
CU2   =   -.158632165645E+00   -.705262493252E-01   -.170837573358E+01    .543998183890E-01
CU    =   -.158632165645E+00   -.705262493252E-01   -.170837573358E+01    .543998183890E-01
C*CU  =   -.741260595896E+00   -.329565822375E+00   -.798315888170E+01    .254207774495E+00
UOLD  =    .130432000000E+03    .272530000000E+03    .165000000000E+03    .775900000000E+02
LNEW  =    .129660719404E+03    .272200434178E+03    .157016841118E+03    .778442077745E+02
P1    =   0.                   -.331144123629E-02   -.166817082427E-01   -.161313377612E-01   -.155810822107E-01   0.
F2    =    .275156852534E+07    .175550961256E+07    .135727768536E+05    .313076213326E+04    .402854679747E+03   0.
F1F2  =    .275156852534E+07    .175550960965E+07    .135727602119E+05    .313074600192E+04    .402839098665E+03   0.

SENSITIVITY MATRIX

   -.118055640878E+06    .912352950190E+04    .392595256546E+04   -.693051012817E+03
    .174252218325E+05    .759658832662E+04   -.823284730842E+04    .595254709957E+02
   -.122555665543E+05   -.406526064529E+05    .135838715037E+04    .237654673108E+04

   -.1E+06   .9E+04   .4E+04  -.7E+03
    .2E+05   .8E+04  -.8E+04   .6E+02
   -.1E+05  -.8E+05   .1E+04   .2E+04
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REFERENCE TRAJECTORY INTEGRATION

U

.125690719404E+03	.272200434178E+03	.157016841110E+03	.778442077745E+02

DELTA U

0.	0.	0.	0.

JULIAN DATE -- 2444481.65478000 | CONTROL PHASE -- 6 | PRIMARY BODY -- SUN
DAYS FROM LAUNCH-- 525.00000000 | PRESENT S/C MASS- 1584.46949691 KG | EPHEMERIS BODY -- ENCKE
DAYS FROM CUTOFF- 68.49870000 | POWER AVAILABLE-- 9.64559498 KW | TARGET BODY -- ENCKE

S/C RELATIVE STATES		X	Y	Z	MAGNITUDE
SUN	POSITION	.226552540008362E+09	.697172425615150E+08	.309288781387640E+08	.239046219491540E+09
	VELOCITY	-.184764395271010E+02	.101458325303590E+02	.612726961769430E+00	.210877258985800E+02
EARTH	POSITION	.876012616608030E+08	.128896488270780E+09	.309288786387640E+08	.158886378485090E+09
	VELOCITY	-.296625807726230E+02	-.171522348134160E+02	.612726961769430E+00	.342704978332850E+02
ENCKE	POSITION	-.215056650501040E+08	-.185012003560850E+08	-.880687168612480E+07	.295551325959250E+08
	VELOCITY	.535862766153120E+01	.473036708755540E+01	.177176829537900E+01	.732782808647000E+01

S/C ACCELERATIONS	X	Y	Z	MAGNITUDE
PRIMARY BODY	-.220107367011620E-05	-.677338621258400E-06	-.300489857180460E-06	.232245711999870E-05
PERTURBING BODIES	-.250879192303390E-10	-.603498363331360E-11	-.311137241712680E-11	.259904865493410E-10
THRUST	-.134752052190820E-06	-.330215039768980E-06	-.401715088784380E-07	.358906447677990E-06
RADIATION PRESSURE	0.	0.	0.	0.

**** CONTROL PHASE CHANGE ****

JULIAN DATE -- 2444523.65478000 | CONTROL PHASE -- 7 | PRIMARY BODY -- SUN
DAYS FROM LAUNCH-- 567.00000000 | PRESENT S/C MASS- 1497.44931065 KG | EPHEMERIS BODY -- ENCKE
DAYS FROM CUTOFF- 26.49870000 | POWER AVAILABLE-- 16.67623038 KW | TARGET BODY -- ENCKE

THRUST PHASE DURATION (DAYS)	THRUST PHASE THROTTLING	THRUST PHASE CONE ANGLE (DEG)	THRUST PHASE CLOCK ANGLE (DEG)	THRUST PHASE CONE RATE (DEG/SEC)	THRUST PHASE CLOCK RATE (DEG/SEC)
10.00000000	1.00000000	150.54000000	80.00000000	0.00000000	0.00000000

S/C RELATIVE STATES		X	Y	Z	MAGNITUDE
SUN	POSITION	.141962507210600E+09	.968708249239590E+08	.301580816835720E+08	.174490606832200E+09
	VELOCITY	-.268966455772540E+02	.363042814373990E+01	-.132923835220140E+01	.291541256316480E+02
EARTH	POSITION	-.586582961826220E+05	.507505502334500E+08	.301580816835720E+08	.590350342994590E+08
	VELOCITY	-.192059844290680E+02	-.245932754879590E+02	-.132923835220140E+01	.312349138216560E+02
ENCKE	POSITION	-.526517608533930E+07	-.512482085170750E+07	-.285575976643990E+07	.832374552818850E+07
	VELOCITY	.342287824060390E+01	.258406729555810E+01	.144837129984010E+01	.452672938621690E+01

S/C ACCELERATIONS	X	Y	Z	MAGNITUDE
PRIMARY BODY	-.354628312752970E-05	-.241988294418220E-05	-.753361567387050E-06	.435983509535680E-05
PERTURBING BODIES	-.170968766233120E-10	-.105120837173080E-09	-.591455381149540E-10	.121822011931680E-09
THRUST	-.470432270882180E-06	-.372762371387450E-07	-.113929206269120E-06	.485852258043240E-06
RADIATION PRESSURE	0.	0.	0.	0.

**** CONTROL PHASE CHANGE ****

JULIAN DATE	-- 2444533.65478000	CONTROL PHASE --	8	PRIMARY BODY	-- SUN
DAYS FROM LAUNCH-	577.00000000	PRESENT S/C MASS-	1470.10836107 KG	EPHEMERIS BODY	-- ENCKE
DAYS FROM CUTOFF-	16.49870000	POWER AVAILABLE--	20.02488822 KW	TARGET BODY	-- ENCKE

THRUST PHASE DURATION (DAYS)	THRUST PHASE THROTTLING	THRUST PHASE CONE ANGLE (DEG)	THRUST PHASE CLOCK ANGLE (DEG)	THRUST PHASE CONE RATE (DEG/SEC)	THRUST PHASE CLOCK RATE (DEG/SEC)
10.00000000	1.00000000	157.01684112	77.84420777	0.00000000	0.00000000

S/C RELATIVE STATES		X	Y	Z	MAGNITUDE
SUN	POSITION	.11541678089737E+09	.98960688879110E+08	.28652189023406E+08	.15470975036728E+09
	VELOCITY	-.32651165331127E+02	.10364269164592E+01	-.22002233236470E+01	.32741645165816E+02
EARTH	POSITION	-.16162926374217E+08	.29262173726982E+08	.28652189023406E+08	.44027979013798E+08
	VELOCITY	-.16221279150050E+02	-.25178706668383E+02	-.22002233236470E+01	.31158036957382E+02
ENCKE	POSITION	-.32270676562586E+07	-.29889293638473E+07	-.17028318733375E+07	.47167044415558E+07
	VELOCITY	.27281926152591E+01	.23493373954781E+01	.13088966924056E+01	.38208787134521E+01

S/C ACCELERATIONS	X	Y	Z	MAGNITUDE
PRIMARY BODY	-.41364351797116E-05	-.35466757115913E-05	-.10268726303772E-05	.55446796115666E-05
PERTURBING BODIES	.60332865559851E-10	-.14686558863171E-09	-.13546259058526E-09	.20879953434292E-09
THRUST	-.54745375243943E-06	-.17139635858199E-06	-.14893695750395E-06	.59267632456101E-06
RADIATION PRESSURE	0.	0.	0.	0.

**** CONTROL PHASE CHANGE ****

JULIAN DATE	-- 2444543.65478000	CONTROL PHASE --	9	PRIMARY BODY	-- SUN
DAYS FROM LAUNCH-	587.00000000	PRESENT S/C MASS-	1443.42710806 KG	EPHEMERIS BODY	-- ENCKE
DAYS FROM CUTOFF-	6.49870000	POWER AVAILABLE--	21.00000000 KW	TARGET BODY	-- ENCKE

THRUST PHASE DURATION (DAYS)	THRUST PHASE THROTTLING	THRUST PHASE CONE ANGLE (DEG)	THRUST PHASE CLOCK ANGLE (DEG)	THRUST PHASE CONE RATE (DEG/SEC)	THRUST PHASE CLOCK RATE (DEG/SEC)
213.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000

S/C RELATIVE STATES		X	Y	Z	MAGNITUDE
SUN	POSITION	.85366600230072E+08	.98242923360523E+08	.26259337203716E+08	.13277304402465E+09
	VELOCITY	-.37009287983207E+02	-.29998750783230E+01	-.34069804797007E+01	.37286747851832E+02
EARTH	POSITION	-.31832263535258E+08	.70533971005001E+07	.26259337203716E+08	.41864096422551E+08
	VELOCITY	-.18230452658750E+02	-.26401705161589E+02	-.34069804797007E+01	.32264635512377E+02
ENCKE	POSITION	-.11568629590449E+07	-.11071704467611E+07	-.64163955509257E+06	.17250680052825E+07
	VELOCITY	.20833115835349E+01	.20012783351406E+01	.11469752871500E+01	.31081915060251E+01

S/C ACCELERATIONS	X	Y	Z	MAGNITUDE
PRIMARY BODY	-.48402754385540E-05	-.55703613334513E-05	-.14885010991161E-05	.75282140784788E-05
PERTURBING BODIES	.16061592531171E-09	-.56327010352500E-10	-.14441304174011E-09	.22171285214522E-09
THRUST	0.	0.	0.	0.
RADIATION PRESSURE	0.	0.	0.	0.

JULIAN DATE	-- 2444550.15347999	CONTROL PHASE	-- 9	PRIMARY BODY	-- SUN
DAYS FROM LAUNCH-	593.49870000	PRESENT S/C MASS-	1443.42710806 KG	EPHEMERIS BODY	-- ENCKE
DAYS FROM CUTOFF-	0.00000000	POWER AVAILABLE--	21.00000000 KW	TARGET BODY	-- ENCKE

S/C RELATIVE STATES		X	Y	Z	MAGNITUDE
SUN	POSITION	.63600462535900E+08	.95574812737329E+08	.24088624683500E+08	.11741064632865E+09
	VELOCITY	-.35845581375078E+02	-.67149795003431E+01	-.42703721314153E+01	.40643369213622E+02
EARTH	POSITION	-.48127190003204E+08	-.81440298152537E+07	.24088624683500E+08	.45206578779332E+08
	VELOCITY	-.16518728916160E+02	-.27890932257515E+02	-.43703731314153E+01	.33763109808030E+02
ENCKE	POSITION	.25341122961044E+03	-.97057816886902E+03	-.29957740068436E+02	.10035620057415E+04
	VELOCITY	.20492971772801E+01	.19524993306343E+01	.11403103982541E+01	.30515865318391E+01

S/C ACCELERATIONS	X	Y	Z	MAGNITUDE
PRIMARY BODY	-.92313165305780E-05	-.78266536745127E-05	-.19751458766427E-05	.96270979371444E-05
PERTURBING BODIES	.12955445975849E-09	.14738005075040E-10	-.81581222708396E-10	.15380852621199E-09
THRUST	0.	0.	0.	0.
RADIATION PRESSURE	0.	0.	0.	0.

** TERMINATION DATA ***

REQUESTED STOPPING CONDITION ; TEND
ACTUAL STOPPING CONDITION ; TEND

FLIGHT TIME .59349870000000E+03
FINAL S/C MASS .14434271080600E+04

X =	.25341122961044E+03	VX =	.20492971772801E+01	FDT =	.87750090067192E+03	RCA =	.89098303248958E+03
Y =	-.97057816886902E+03	VY =	.19524993306343E+01	ECR =	-.15363350382142E+03	VCA =	.30515865318392E+01
Z =	-.29957740068436E+02	VZ =	.11403103982541E+01	VHP =	.30515865318388E+01	ICA =	.23988722912594E+02
R =	.10035620057415E+04	V =	.30515865318391E+01	TSOI =	.59349872954212E+03	TRCA =	.59350045235871E+03

CONIC ELEMENTS	A	E	INC	NODE	APS	MA	TA
S/C TARGET CENT	-.107386E-09	.829606E+13	.239887E+02	.288481E+03	.232310E+02	-.430243E+13	.332588E+03

****

****
* CURRENT CP TIME 21.718 *
****

3.2.2 GODSEP

The GODSEP sample case uses a targeted Encke flyby trajectory, generated by TOPSEP, and performs a short error analysis over the terminal mission phase near encounter. The run actually consists of two cases, the first to create an STM file containing appropriate state transition matrices and the second case performs the error analysis.

The first page of output is a reproduction of the $TRAJ and $GØDSEP namelist used to create the STM file. Of particular interest in $TRAJ are the variables MØDE = 2 (for GODSEP), ISTMF = 1 (for STM generation), and IAUGDC (for augmenting the basic spacecraft state vector with ephemeris body state and thrust bias parameters). The $GØDSEP namelist specifies only one scheduling card along with the STM time span from launch + 543 days through encounter at L + 593.5 days. The scheduling card follows $GØDSEP and is a dummy measurement to create transition matrices at half day intervals.

The next page contains MAPSEP initialization print. This is followed, on the next three and one-half pages, by the GØDSEP initialization print and the standard TRAJ print blocks which are displayed during the creation of the STM file. STM generation ends with the output of the last STM record covering the next two and one-half pages. This contains trajectory related data such as current (TCURR) and previous (TPAST) STM time points, and finally the transition matrix (PHI) over the interval TPAST to TCURR.

Next, the namelists $TRAJ and $GØDSEP are shown for the subsequent error analysis using the previously generated STM file. With ISTMF = 2 in $TRAJ, reference trajectory data is obtained from the STM file. $GØDSEP

namelist for the second case specifies a spherical a-priori knowledge covariance, one guidance event executing at L + 567 days with a half day delay time, and no measurement print. The total augmented state consists of 15 solve-for parameters (S/C state, thrust biases and Encke's state) and nine consider parameters (tracking station location biases).

Four scheduling cards specify (1) simultaneous 2-way/3-way doppler measurements twice per day from Goldstone and Madrid, (2) 2-way range once per day from Madrid, (3) 3-way range once per day from Goldstone and Madrid, and (4) three simultaneous star-Encke angle measurements taken twice per day.

Output from the error analysis run begins with MAPSEP initialization print followed by four pages of GODSEP initialization print, including the input a-priori covariance.

The first event printed is a low thrust guidance correction. This begins with generation of required transition and sensitivity matrices, as represented by TRAJ print at 566.5 days (last effective time of tracking to be used for guidance computations), 567 days (beginning of guidance interval over which thrust control corrections will be computed), 587 days (end of guidance interval and time of nominal thrust shutdown), and 593.5 days (desired target time and time of nominal Encke encounter). After the TRAJ print, the sensitivity matrix of guidance cutoff state with respect to thrust control parameters is shown.

The knowledge (estimation error) covariance is printed at guidance

initiation. Since the Encke ephemeris is part of the augmented state, the Encke relative S/C knowledge covariance is also displayed. After the knowledge covariance, the control (actual error) covariance is shown in analgous fashion.

After the knowledge and control covariances, VMAT and SMAT are printed. These are sensitivity matrices of target parameters WRT guidance initiation state and target parameters WRT thrust control parameters, respectively. VMAT, SMAT and BURNP (S/C mass and thrust acceleration magnitude at guidance start and end) are also provided on punched cards to be used in subsequent GODSEP runs in order to minimize computational time (See $GEVENT in Section 2.3.3).

Guidance corrections are computed next. The reader is referred to Section 6.6 of the Analytic Manual to better understand the actual guidance computation logic. The guidance cycle uses the various sensitivity matrices, thrust control constraints, and control and target weighting in ultimately computing a "final" set of control corrections. Included is the additional propellant needed to execute these corrections, in this case .8677 Kg. The GAMMA matrix is the final guidance matrix of control corrections WRT guidance initiation state error.

Finally, the guidance event ends with a display of the new control covariance, which assumes all guidance corrections have occurred, and the projected target dispersions before and after guidance initiation.

The next event printed is a "thrust" event which is the same as an "eigenvector" event at the time of a nominal change in thrust

C-2

control policy or a change in the number of operating thrusters. In this case, both control policy and number of thrusters have been changed. The information printed is a standard TRAJ print followed by eigenvalues, eigenvectors and covariances of the heliocentric state and of the S/C relative state (WRT Encke).

A measurement event is printed for a star-planet angle observation with three stars. The TRAJ print is followed by the knowledge covariance before measurement processing. Navigation related matrices are output which include the observation matrix of augmented state WRT the measurement (three star-planet angles taken simultaneously) and the filter gain matrix. The knowledge covariance is then printed after the measurement(s) have been processed.

The final event shown is a "zero burn" guidance event. This occurs automatically (if a previous guidance event has been executed) at termination time (TFINAL = 570 days in $GØDSEP) to display the final knowledge and control covariances.

For this GODSEP run, the contents of the SUMARY file are printed. Results of every measurement (before and after processing) are displayed and include measurement time and code, RSS S/C position and velocity, and the standard deviations of the knowledge covariances for both S/C state and augmented solve-for parameters.

The user should read pages 31-34 on output control for a better understanding of GODSEP flexibility in terms of printout.

```
PSTRAJ
   ENGINE = 21.65, 0.65, 21.65,
   ENGINE(11) = 0.64,
   NB = 3, 10,
   NTP = 10,
   TLNCH = 2443956.65478,
   THRUST =
   9., 64., 8*0.,
   1., 140., 1., 68.1, 224.6, 5*0.,
   1., 230., 1., 75., 252., 5*0.,
   1., 470., 1., 85.33, 269., 5*0.,
   1., 525., 1., 120.501, 268.742, 5*0.,
   1., 567., 1.355, 129.6743, 272.2092, 2*0., 6., 2*0.,
   1., 577., 1., 150.64, 80., 2*0., 7., 2*0.,
   1., 587., 1., 156.8814, 78.0227, 2*0., 7., 2*0.,
   9., 800., 8*0.,
  IAUGDC=3*1,
   ICOORD = 0,
   TSTART = 543.,
   TEND = 593.5,
   NLP = 0,
   ISTOP = 1,
   MODE = 2,
  IPHINT=5,
   SCMASS = 1551.3588,
   STATE = 1.948380955494E8, 8.408465356688O2E7, 3.142154020684867E7,
          -22.4042728712537, 8.18889592239259, -.014340334276913,
   ISTMF = 1,
 $ END TRAJ    ENCKE FLYBY APPROACH PHASE

 $GODSEP
  NSCHED=1,
  TCURR=543.,   TFINAL=593.5,
 $END GODSEP

  553.      593.5      .5          1001
```

TRAJECTORY INITIALIZATION

INITIAL EPOCH (REFERENCE DATE)
JULIAN DATE 2443956.6547800004
CALENDAR DATE .... 1979 MAR 24 3 HR 42 MIN 52.9920 SECS
TRAJECTORY START EPOCH 543.0000000000 DAYS AFTER THE INITIAL EPOCH
JULIAN DATE 2444499.6547800004
CALENDAR DATE .... 1980 SEP 17 3 HR 42 MIN 52.9920 SECS
TRAJECTORY END EPOCH 593.5000000000 DAYS AFTER THE INITIAL EPOCH
JULIAN DATE 2444550.1547800004
CALENDAR DATE .... 1980 NOV 6 15 HR 42 MIN 52.9920 SECS

INITIAL STATE VECTOR AT 543.0000000000 DAYS AFTER THE REFERENCE EPOCH

	X	Y	Z	MAGNITUDE
POSITION	.19463809554940E+09	.84384653566860E+08	.31421540206849E+08	.21452138735275E+09
VELOCITY	-.22404272871254E+02	.81888559223926E+01	-.14340334276914E-01	.23353923471047E+02

SEPS MASS 1551.3588000000 KG
EXHAUST VELOCITY 29.4180000000 KM/SEC
ELECTRIC POWER AT 1 A. U. 21.6500000000 KW
THRUSTER EFFICIENCY .6400000000
RADIATION PRESSURE COEFFICIENT -1.0000000000

LIST OF GRAVITATING BODIES
SUN
EARTH
ENCKE
TARGET PLANET IS ENCKE

INTEGRATION STEP FACTOR .0500

REFERENCE THRUST CONTROLS

THRUST PHASE NUMBER	THRUST PHASE END TIME (DAY)	THRUST PHASE THROTTLING	THRUST PHASE CONE ANGLE (DEG)	THRUST PHASE CLOCK ANGLE (DEG)	THRUST PHASE CONE RATE (DEG/SEC)	THRUST PHASE CLOCK RATE (DEG/SEC)	NUMBER OF THRUSTERS
1	64.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2	140.000000	1.000000	68.100000	224.600000	0.000000	0.000000	0.000000
3	230.000000	1.000000	75.000000	252.000000	0.000000	0.000000	0.000000
4	470.000000	1.000000	65.334000	269.000000	0.000000	0.000000	0.000000
5	525.000000	1.000000	120.501000	268.742000	0.000000	0.000000	0.000000
6	567.000000	1.355300	129.674300	272.209200	0.000000	0.000000	6.000000
7	577.000000	1.000000	150.640000	80.000000	0.000000	0.000000	7.000000
8	587.000000	1.000000	156.881400	78.022700	0.000000	0.000000	7.000000
9	800.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000

BODY PARAMETERS AND ORBITAL ELEMENTS HAVE BEEN READ-IN FOR ENCKE AT JULIAN DATE....2444580.000000000000
PLANET RADIUS .500000000000E+03 KM
PLANET SPHERE .100000000000E+04 KM
PLANET GRAVITATIONAL CONSTANT .100000000000E-08 KM**3/SEC**2

SEMI-MAJOR AXIS	.331806126700E+09	KM	0.	KM/JC
ECCENTRICITY	.847000000000E+00		0.	1.0/JC
INCLINATION	.119500000000E+02	DEG	0.	DEG/JC
ASCENDING NODE	.334200000000E+03	DEG	0.	DEG/JC
OMEGA-T	.162000000000E+03	DEG	0.	DEG/JC
MEAN ANOMALY	0.	DEG	0.	DEG/JC

ORIGINAL PAGE IS OF POOR QUALITY

JOB NO.
RUN DATE 08/30/74

SCHEDULED TRAJECTORY TIME 543.0000 DAYS
STM FILE TRAJECTORY TIME 543.0000 DAYS

MEASUREMENT AND PROPAGATION EVENT SCHEDULE

FROM 553.00000 DAYS TO 593.50000 DAYS IN INCREMENTS OF .50000 DAYS -- CODE NO. 1001

0 EIGENVECTOR EVENTS

3 THRUST EVENTS

EVENT TIME (DAYS)	TYPE
567.000	0
577.000	0
587.000	0

0 GUIDANCE EVENTS

0 PREDICTION EVENTS

CURRENT RUN SEGMENT CREATES STM FILE

JULIAN DATE -- 2444459.65478000	CONTROL PHASE -- 6	PRIMARY BODY -- SUN
DAYS FROM LAUNCH- 543.00000000	PRESENT S/C MASS- 1551.35880000 KG	EPHEMERIS BODY -- ENCKE
DAYS FROM CUTOFF- 50.50000000	POWER AVAILABLE-- 11.75187839 KW	TARGET BODY -- ENCKE

S/C RELATIVE STATES		X	Y	Z	MAGNITUDE
SUN	POSITION	.194838095549400E+09	.840846535668000E+08	.314215402068649E+08	.214521367352750E+09
	VELOCITY	-.224042728712540E+02	.818889592239260E+01	-.143403342769140E-01	.238539234710470E+02
EARTH	POSITION	.452113349807220E+08	.987210832294140E+08	.314215402068490E+08	.113036411273970E+09
	VELOCITY	-.248183911599490E+02	-.213497931485400E+02	-.143403342769140E-01	.327378437726790E+02
ENCKE	POSITION	-.139601602634320E+08	-.120737526678050E+08	-.613395682111220E+07	.194477394911110E+08
	VELOCITY	.441583667530060E+01	.401142938362130E+01	.166016565943360E+01	.615252311437900E+01

S/C ACCELERATIONS	X	Y	Z	MAGNITUDE
PRIMARY BODY	-.261923166265720E-05	-.113035598606330E-05	-.422403497463700E-06	.288383649248410E-05
PERTURBING BODIES	-.303985331644410E-10	-.258425264358590E-10	-.877849787087010E-11	.408533172203540E-10
THRUST	-.121077898186340E-06	-.426371013172550E-06	-.548715546598910E-07	.446612790315550E-06
RADIATION PRESSURE	0.	0.	0.	0.

JULIAN DATE -- 2444499.65478000
DAYS FROM LAUNCH- 543.00000000
DAYS FROM CUTOFF- 50.50000000

CONTROL PHASE -- 6
PRESENT S/C MASS- 1551.35880000 KG
POWER AVAILABLE-- 11.75187839 KW

PRIMARY BODY -- SUN
EPHEMERIS BODY -- ENCKE
TARGET BODY -- ENCKE

S/C RELATIVE STATES		X	Y	Z	MAGNITUDE
SUN	POSITION	.19482809554940E+09	.84084653566800E+08	.31421540206849E+08	.21452108735275E+09
	VELOCITY	-.22404272871254E+02	.81888959223926E+01	-.14340334276914E-01	.23853920471047E+02
EARTH	POSITION	.45211334980722E+08	.98721083229414E+08	.31421540206849E+08	.11303641127397E+09
	VELOCITY	-.24818391159949E+02	-.21349793148540E+02	-.14340334276914E-01	.32737643772879E+02
ENCKE	POSITION	-.13960160263432E+08	-.12070752637805E+08	-.61339568211122E+07	.19447739451111E+08
	VELOCITY	.44158366750006E+01	.40114293816213E+01	.16601696594336E+01	.61925031140795E+01

S/C ACCELERATIONS	X	Y	Z	MAGNITUDE
PRIMARY BODY	-.26192316626572E-05	-.11303599800433E-05	-.42240349746370E-06	.28838364924841E-05
PERTURBING BODIES	-.30398533164441E-10	-.25642526435859E-10	-.87784978708731E-11	.40893017223354E-10
THRUST	-.12107789018634E-06	-.42637101387255E-06	-.54871554659891E-07	.44661279331559E-06
RADIATION PRESSURE	0.	0.	0.	0.

JULIAN DATE -- 2444514.41978499
DAYS FROM LAUNCH- 557.76530499
DAYS FROM CUTOFF- 35.73499501

CONTROL PHASE -- 6
PRESENT S/C MASS- 1518.18693029 KG
POWER AVAILABLE-- 14.37392785 KW

PRIMARY BODY -- SUN
EPHEMERIS BODY -- ENCKE
TARGET BODY -- ENCKE

S/C RELATIVE STATES		X	Y	Z	MAGNITUDE
SUN	POSITION	.16390977308027E+09	.93684440940458E+08	.30970574851661E+08	.19122435282035E+09
	VELOCITY	-.26184348191966E+02	.57598945626865E+01	-.73208910490927E+00	.26820373414261E+02
EARTH	POSITION	.15985451537131E+08	.69972791025579E+08	.30970574851661E+08	.78172262672879E+08
	VELOCITY	-.21099950679105E+02	-.23563202051286E+02	-.73208910490927E+00	.31638106449438E+02
ENCKE	POSITION	-.87541729178553E+07	-.74424959974459E+07	-.40894193416719E+07	.12196296164762E+08
	VELOCITY	.37629763822206E+01	.32079231818838E+01	.15402164715836E+01	.51792994054025E+01

S/C ACCELERATIONS	X	Y	Z	MAGNITUDE
PRIMARY BODY	-.31200882057271E-05	-.17722407214769E-05	-.58965078707636E-06	.36369250601671E-05
PERTURBING BODIES	-.31287660041191E-10	-.51883080813352E-10	-.26160078325937E-10	.74113276567417E-10
THRUST	-.91439563911748E-07	-.54564394210297E-06	-.74119594448584E-07	.55819555310196E-06
RADIATION PRESSURE	0.	0.	0.	0.

**** CONTROL PHASE CHANGE ****

JULIAN DATE -- 2444523.65478000
DAYS FROM LAUNCH- 567.00000000
DAYS FROM CUTOFF- 26.50000000

CONTROL PHASE -- 7
PRESENT S/C MASS- 1493.44521117 KG
POWER AVAILABLE-- 16.07711523 KW

PRIMARY BODY -- SUN
EPHEMERIS BODY -- ENCKE
TARGET BODY -- ENCKE

THRUST PHASE DURATION (DAYS)	THRUST PHASE THROTTLING	THRUST PHASE CONE ANGLE (DEG)	THRUST PHASE CLOCK ANGLE (DEG)	THRUST PHASE CONE RATE (DEG/SEC)	THRUST PHASE CLOCK RATE (DEG/SEC)
10.00000000	1.00000000	150.64000000	80.00000000	0.00000000	0.00000000

S/C RELATIVE STATES		X	Y	Z	MAGNITUDE
SUN	POSITION	.14195570322314E+09	.96870267382273E+08	.30157651202297E+08	.17448425232292E+09
	VELOCITY	-.28896602672674E+02	.36298848109232E+01	-.13296282774445E+01	.29154032673357E+02
EARTH	POSITION	-.65462275323868E+05	.50750232751764E+08	.30157651202297E+08	.59034516171212E+08
	VELOCITY	-.15209941524488E+02	-.24593818820776E+02	-.13296282774445E+01	.31235317578233E+02
ENCKE	POSITION	-.58919800684805E+07	-.51251780973935E+07	-.28962304477153E+07	.83289273257134E+07
	VELOCITY	.34229211451836E+01	.25835239637414E+01	.14480813745970E+01	.45263589014603E+01

S/C ACCELERATIONS	X	Y	Z	MAGNITUDE
PRIMARY BODY	-.35466673190831E-05	-.24201010911728E-05	-.75342647524620E-06	.43591253275064E-05
PERTURBING BODIES	-.17063529376056E-10	-.10512256725169E-09	-.59146257081069E-10	.12182315399928E-09
THRUST	-.47085746419581E-06	-.37287901309504E-07	-.11393693149883E-06	.48587937137972E-06
RADIATION PRESSURE	0.	0.	0.	0.

JULIAN DATE -- 2444525.99414107		CONTROL PHASE -- 7		PRIMARY BODY -- SUN	
DAYS FROM LAUNCH- 569.33936108		PRESENT S/C MASS- 1488.35719453 KG		EPHEMERIS BODY -- ENCKE	
DAYS FROM CUTOFF- 24.16063892		POWER AVAILABLE-- 17.37079368 KW		TARGET BODY -- ENCKE	

S/C RELATIVE STATES		X	Y	Z	MAGNITUDE
SUN	POSITION	.13613263268787E+09	.97552650135938E+08	.29870794048977E+08	.17003546978838E+09
	VELOCITY	-.29723146322867E+02	.31107677227759E+01	-.15198469354003E+01	.29923651907E+02
EARTH	POSITION	-.39159615279617E+07	.45766517988636E+08	.29870794048977E+08	.54792396525740E+08
	VELOCITY	-.18699248249567E+02	-.24718067064968E+02	-.15108409354003E+01	.31152023627696E+02
ENCKE	POSITION	-.52164328228779E+07	-.46079139321418E+07	-.26065946392688E+07	.74322525397815E+07
	VELOCITY	.32615219129789E+01	.25342862726525E+01	.14176724588526E+01	.43664127880166E+01

S/C ACCELERATIONS	X	Y	Z	MAGNITUDE
PRIMARY BODY	-.36720896633341E-05	-.26332963610017E-05	-.60632310428966E-06	.45899953000677E-05
PERTURBING BODIES	-.73889996799515E-11	-.11695306559251E-09	-.76272485952823E-10	.13956482046035E-09
THRUST	-.49.79733141166E-06	-.50232634925934E-07	-.12031308769390E-06	.50781943373747E-06
RADIATION PRESSURE	0.	0.	0.	0.

**** CONTROL PHASE CHANGE ****

JULIAN DATE -- 2444533.65478000	CONTROL PHASE -- 8	PRIMARY BODY -- SUN
DAYS FROM LAUNCH- 577.00000000	PRESENT S/C MASS- 1473.10300756 KG	EPHEMERIS BODY -- ENCKE
DAYS FROM CUTOFF- 16.50000000	POWER AVAILABLE-- 20.02597695 KW	TARGET BODY -- ENCKE

THRUST PHASE DURATION (DAYS)	THRUST PHASE THROTTLING	THRUST PHASE CONE ANGLE (DEG)	THRUST PHASE CLOCK ANGLE (DEG)	THRUST PHASE CONE RATE (DEG/SEC)	THRUST PHASE CLOCK RATE (DEG/SEC)
10.00700000	1.00000000	156.88140000	78.02270000	0.00000000	0.00000000

S/C RELATIVE STATES		X	Y	Z	MAGNITUDE
SUN	POSITION	.11540953088758E+09	.98959755849401E+08	.28651477920106E+08	.15477391166026E+09
	VELOCITY	-.32651345032773E+02	.10356176178578E+01	-.22005865508062E+01	.32741799239200E+02
EARTH	POSITION	-.16169776384010E+08	.29261240697272E+08	.28651477920106E+08	.44029411334438E+08
	VELOCITY	-.18221434891695E+02	-.25179515986374E+02	-.22005865508062E+01	.31158207656271E+02
ENCKE	POSITION	-.32339176660514E+07	-.25898623935566E+07	-.17035429766371E+07	.47222409163182E+07
	VELOCITY	.27280369176535E+01	.23485280968867E+01	.13085334652464E+01	.38301474482866E+01

S/C ACCELERATIONS	X	Y	Z	MAGNITUDE
PRIMARY BODY	-.41366580114137E-05	-.35470438506568E-05	-.10269634125149E-05	.55450981445345E-05
PERTURBING BODIES	.60357794717573E-10	-.14684767669130E-09	-.13544603917059E-09	.20669337560443E-09
THRUST	-.54805230111285E-06	-.17305157545375E-06	-.14841535032206E-06	.59271070049186E-06
RADIATION PRESSURE	0.	0.	0.	0.

JULIAN DATE -- 2444535.60788515	CONTROL PHASE -- 8	PRIMARY BODY -- SUN
DAYS FROM LAUNCH- 578.95310515	PRESENT S/C MASS- 1465.00829200 KG	EPHEMERIS BODY -- ENCKE
DAYS FROM CUTOFF- 14.54689485	POWER AVAILABLE-- 20.80645030 KW	TARGET BODY -- ENCKE

S/C RELATIVE STATES		X	Y	Z	MAGNITUDE
SUN	POSITION	.10983226861993E+09	.99060093059844E+08	.28263030095739E+08	.15059479357747E+09
	VELOCITY	-.33454420666578E+02	.38149693063193E+00	-.24055078098952E+01	.33542981554867E+02
EARTH	POSITION	-.19237037281517E+08	.24598405581122E+08	.28263030095799E+08	.42353072558934E+08
	VELOCITY	-.18139578756821E+02	-.25345479232758E+02	-.24055078098952E+01	.31260522667761E+02
ENCKE	POSITION	-.27848489012542E+07	-.25589500249766E+07	-.14853219127159E+07	.40285324571134E+07
	VELOCITY	.25543770482434E+01	.22840585091.83E+01	.12776316160602E+01	.36651133355711E+01

S/C ACCELERATIONS	X	Y	Z	MAGNITUDE
PRIMARY BODY	-.42678773937683E-05	-.38500678792001E-05	-.10982487690626E-05	.58518330763236E-05
PERTURBING BODIES	.66370322799729E-10	-.14184122763435E-09	-.15011074339716E-09	.22085740050108E-09
THRUST	-.56645983724471E-06	-.19135187558717E-06	-.15011619438718E-06	.61795199234471E-06
RADIATION PRESSURE	0.	0.	0.	0.

```
                        ****            CONTROL PHASE CHANGE            ****

JULIAN DATE    -- 2444543.65478000          CONTROL PHASE  --    9                      PRIMARY BODY    -- SUN
DAYS FROM LAUNCH-     587.00000000          PRESENT S/C MASS- 1443.42143055  KG         EPHEMERIS BODY  -- ENCKE
DAYS FROM CUTOFF-       6.50000000          POWER AVAILABLE--   21.00000000  KW         TARGET BODY     -- ENCKE

                   THRUST PHASE   THRUST PHASE   THRUST PHASE   THRUST PHASE   THRUST PHASE   THRUST PHASE
                     DURATION      THROTTLING     CONE ANGLE    CLOCK ANGLE     CONE RATE      CLOCK RATE
                      (DAYS)                        (DEG)          (DEG)        (DEG/SEC)      (DEG/SEC)
                   213.00000000    0.00000000     0.00000000     0.00000000     0.00000000     0.00000000

S/C RELATIVE STATES              X                         Y                         Z                      MAGNITUDE
SUN      POSITION       .65359278621718E+08       .96241636958953E+08       .26258478682948E+08       .13276721652111E+09
         VELOCITY      -.37310353693670E+02      -.29999262299413E+01      -.34069605903825E+01       .37287760674560E+02

EARTH    POSITION      -.31839685143612E+08       .70521127169302E+07       .26258478682948E+08       .41868909068516E+08
         VELOCITY      -.18231418566213E+02      -.26401756313207E+02      -.34069605963825E+01       .32205224931243E+02

ENCKE    POSITION      -.11641845673985E+07      -.11084546283310E+07      -.64249807585990E+06       .17311272601698E+07
         VELOCITY       .20823458763717E+01       .20012271865223E+01       .11409951734682E+01       .31075157605963E+01

S/C ACCELERATIONS                X                         Y                         Z                      MAGNITUDE
PRIMARY BODY           -.48404976353861E-05      -.55710220253654E-05      -.14890484786889E-05       .75288756827845E-05
PERTURBING BODIES       .16059981574059E-09      -.50036574623721E-10      -.14435852878122E-09       .22165816735095E-09
THRUST                  0.                        0.                        0.                        0.
RADIATION PRESSURE      0.                        0.                        0.                        0.
          TCURR      593.5700
          TFAST      593.0000
          NFPI              0
          NTPHAS            9
          AFEPT
             .12951375E-09     .14737696E-10     -.81533734E-10
             .12951374E-09     .14737691E-10     -.81533736E-10
             .15827440E-16     .46660264E-17      .16563553E-17
            0.                0.                 0.
            0.                0.                 0.
            0.                0.                 0.
            0.                0.                 0.
            0.                0.                 0.
            0.                0.                 0.
            0.                0.                 0.
            0.                0.                 0.
            0.                0.                 0.
          APRIM      -.52314761E-05    -.78382331E-05    -.19754773E-05
          MASS        .14434214E+04
          FPACC      0.                0.                0.
          TPACC      0.                0.                0.
          UF
            0.                0.                 0.
             .10592526E+09     .10372123E+09     0.
             .23795504E+08     .55574816E+08      .24068036E+08
            0.                0.                 0.
            0.                0.                 0.
            0.                0.                 0.
            0.                0.                 0.
            0.                0.                 0.
            0.                0.                 0.
            0.                0.                 0.
            0.                0.                 0.
            0.                0.                 0.
          VF
            0.                0.                 0.
           -.21327307E+02     .21175478E+02     0.
           -.41895436E+02    -.86683590E+01     -.55109053E+01
            0.                0.                 0.
            0.                0.                 0.
            0.                0.                 0.
            0.                0.                 0.
            0.                0.                 0.
            0.                0.                 0.
            0.                0.                 0.
            0.                0.                 0.
            0.                0.                 0.
```

UREL

.63788093E+08	.95572631E+08	.24087260E+08
-.42137165E+08	-.81445961E+07	.24087260E+08
-.74111176E+04	-.21848429E+04	-.77557588E+03
0.	0.	0.
0.	0.	0.
0.	0.	0.
0.	0.	0.
0.	0.	0.
0.	0.	0.
0.	0.	0.
0.	0.	0.
0.	0.	0.

URELP

.11740206E+09
.49215205E+08
.77652899E+04
0.
0.
0.
0.
0.
0.
0.
0.
0.

VREL

-.39847204E+02	-.67163725E+01	-.43706750E+01
-.16519897E+02	-.27891851E+02	-.43706750E+01
.20482325E+01	.19519865E+01	.11402303E+01
0.	0.	0.
0.	0.	0.
0.	0.	0.
0.	0.	0.
0.	0.	0.
0.	0.	0.
0.	0.	0.
0.	0.	0.
0.	0.	0.

VRELP

.40644952E+02
.33764548E+02
.30505136E+01
0.
0.
0.
0.
0.
0.
0.
0.
0.

```
CTRUE       .63786093E+08   .95572631E+03   .24087260E+08
VTRUE      -.39847204E+02  -.67163725E+01  -.43766750E+01
CTRUEM      .11743206E+09
VTRUEM      .40644952E+02
WPCHER      .21300000E+02
ET
  -.55115137E-06  -.26362509E-06  -.16570613E-06
   .25443812E-06  -.57548832E-06   .69274678E-07
  -.70475594E-07  -.24692920E-08   .23833570E-06
ETSAVE
  -.55115137E-06  -.26362509E-06  -.16570613E-06
   .25443812E-06  -.57548832E-06   .69274678E-07
  -.70475594E-07  -.24692920E-08   .23833570E-06
PHI
      .99999370E+00   .99359937E-04   .25159666E-04  -.34846056E-09   .46508752E-08   .11747352E-08
     0.              0.              0.              0.              0.              0.
     0.              0.              0.              .99369937E-04   .10000712E+01   .36822653E-04
      .46508752E-08   .33983287E-08   .17399826E-08  0.              0.              0.
     0.              0.              0.              0.              0.              0.
      .25159666E-04   .36822653E-04   .99993511E+00   .11747352E-08   .17399826E-08  -.30498682E-08
     0.              0.              0.              0.              0.              0.
     0.              0.              0.              .43200000E+05  0.              0.
      .99999125E+00   .10154787E-03   .25588897E-04  0.              0.              0.
     0.              0.              0.              0.              0.              0.
     0.               .43200000E+05  0.              .10154787E-03   .10000756E+01   .38344596E-04
     0.              0.              0.              0.              0.              0.
     0.              0.              0.              0.              0.              .43200000E+05
      .25588897E-04   .38344596E-04   .99993314E+00  0.              0.              0.
     0.              0.              0.              0.              0.              0.
     0.              0.              0.              0.              0.              0.
      .10000000E+01  0.              0.              0.              0.              0.
     0.              0.              0.              0.              0.              0.
     0.              0.              0.              0.              .10000000E+01  0.
     0.              0.              0.              0.              0.              0.
     0.              0.              0.              0.              0.              0.
     0.              0.              .10000000E+01  0.              0.              0.
     0.              0.              0.             -.15382250E-15  -.45557618E-15  -.26346834E-15
    -.79924108E-16  -.37169928E-16  -.13195593E-16  0.              0.              0.
      .99999378E+00   .99046920E-04   .25111459E-04  -.34684333E-09   .46430966E-08   .11736487E-08
    -.45557618E-15  -.59862767E-16  -.23769617E-15  -.37169928E-16   .35171636E-16  -.38938031E-17
     0.              0.              0.              .99046920E-04   .10000739E+01   .36726006E-04
      .46430966E-08   .33909944E-08   .17375866E-08  -.26346834E-15  -.23769617E-15   .21368527E-15
    -.13195593E-16  -.38938031E-17   .44752502E-16  0.              0.              0.
      .25111459E-04   .36726006E-04   .99993535E+00   .11736487E-08   .17375866E-08  -.30441511E-08
     0.              0.              0.             -.34525677E-11  -.16052853E-11  -.56978615E-12
     0.              0.              0.              .43200000E+05  0.              0.
      .99999126E+00   .10153485E-03   .25590163E-04  0.              0.              0.
    -.16052853E-11   .15194732E-11  -.16797460E-12  0.              0.              0.
     0.               .43200000E+05  0.              .10153485E-03   .10000756E+01   .38337736E-04
     0.              0.              0.             -.56978615E-12  -.16797460E-12   .19330944E-11
     0.              0.              0.              0.              0.              .43200000E+05
      .25590163E-04   .38337736E-04   .99993315E+00
```

```
$TRAJ
 ISTMF=2,
$END TRAJ - STMFILE READ

P$GODSEP
   IPFORM = 1,
   P(1,1) = 10000.,    P(2,2) = 10000.,    P(3,3) = 10000.,
   P(4,4) = .005,      P(5,5) = .005,      P(6,6) = .005,
   PS(1,1) = .022,     PS(2,2) = .035,     PS(3,3) = .035,
   PS(4,4) = 3000.,    PS(5,5) = 3000.,    PS(6,6) = 3000.,
   PS(7,7) = .001,     PS(8,8) = .001,     PS(9,9) = .001,
   IAUG = 9*1,
   IAUG(18) = 9*2,
  NSCHED=4,
  MPFREQ=11*0,
  EPSIG=.035,2*.01,
  TCURR=563.,  TFINAL=570.,
  NGUID=1,
  TGUID=567.,  TDELAY=.5,
  TCUTOF=587.,
  TIMFTA=563.5,  IGPOL=1,
 $ END GODSEP--TEST CASE

  563.5     570.       .5          1212
  564.      570.       1.          2002
  564.      570.       1.          2121
  563.5     570.       .5          4123
```

ORIGINAL PAGE IS OF POOR QUALITY

TRAJECTORY INITIALIZATION

```
INITIAL EPOCH (REFERENCE DATE)
     JULIAN DATE ....   2443956.6547800004
     CALENDAR DATE ....  1979 MAR   24       3 HR 42 MIN 52.9920 SECS
TRAJECTORY START EPOCH       543.0000000000 DAYS AFTER THE INITIAL EPOCH
     JULIAN DATE ....   2444499.6547800004
     CALENDAR DATE ....  1980 SEP   17       3 HR 42 MIN 52.9920 SECS
TRAJECTORY END EPOCH       593.5000000000 DAYS AFTER THE INITIAL EPOCH
     JULIAN DATE ....   2444550.1547800004
     CALENDAR DATE ....  1980 NOV    6      15 HR 42 MIN 52.9920 SECS

INITIAL STATE VECTOR AT       543.0000000000 DAYS AFTER THE REFERENCE EPOCH
```

	X	Y	Z	MAGNITUDE
POSITION	.19483609554940E+09	.84084E5S5E6860E+08	.31421540226849E+08	.21+5.138735275E+09
VELOCITY	-.22404272871254E+02	.81888559223926E+01	-.14340334276914E-01	.23852923471947E+02

```
SEPS MASS                                 1551.3588000000 KG
EXHAUST VELOCITY                            29.4180000000 KM/SEC
ELECTRIC POWER AT 1 A. U.                   21.6500000000 KW
THRUSTER EFFICIENCY                           .6430000000
RADIATION PRESSURE COEFFICIENT              -1.0000000000

LIST OF GRAVITATING BODIES
     SUN
     EARTH
     ENCKE
 * TARGET PLANET IS ENCKE

INTEGRATION STEP FACTOR       .0500
```

REFERENCE THRUST CONTROLS

THRUST PHASE NUMBER	THRUST PHASE END TIME (DAY)	THRUST PHASE THROTTLING	THRUST PHASE CONE ANGLE (DEG)	THRUST PHASE CLOCK ANGLE (DEG)	THRUST PHASE CONE RATE (DEG/SEC)	THRUST PHASE CLOCK RATE (DEG/SEC)	NUMBER OF THRUSTERS
1	64.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2	140.000000	1.000000	68.100000	224.600000	0.000000	0.000000	0.000000
3	250.000000	1.000000	75.000000	252.000000	0.000000	0.000000	0.000000
4	470.000000	1.000000	85.334000	269.000000	0.000000	0.000000	0.000000
5	525.000000	1.000000	120.501000	268.742000	0.000000	0.000000	0.000000
6	567.000000	1.355000	129.674300	272.209200	0.000000	0.000000	6.000000
7	577.000000	1.000000	153.640000	80.000000	0.000000	0.000000	7.000000
8	587.000000	1.000000	156.881400	78.022700	0.000000	0.000000	7.000000
9	803.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000

```
BODY PARAMETERS AND ORBITAL ELEMENTS HAVE BEEN READ-IN FOR ENCKE  AT JULIAN DATE....2444580.00000000000
     PLANET RADIUS                   .50000000000000E+03 KM
     PLANET SPHERE                   .10000000000000E+04 KM
     PLANET GRAVITATIONAL CONSTANT   .10000000000000E-08 KM**3/SEC**2
     SEMI-MAJOR AXIS    .33100812670000E+09 KM    0.                  KM/JC
     ECCENTRICITY       .84700000000000E+00       0.                  1.0/JC
     INCLINATION        .11950000000000E+02 DEG   0.                  DEG/JC
     ASCENDING NODE     .33420000000000E+03 DEG   0.                  DEG/JC
     OMEGA-T            .16520000000000E+03 DEG   0.                  DEG/JC
     MEAN ANOMALY     0.                  DEG   0.                  DEG/JC
```

ORIGINAL PAGE IS OF POOR QUALITY

JOB NO.
RUN DATE 08/30/74

SCHEDULED TRAJECTORY TIME 563.0000 DAYS
STM FILE TRAJECTORY TIME 563.0000 DAYS

TOTAL JOB FIELD LENGTH = 070200 OCTAL
LENGTH OF BLANK COMMON = 011577

MEASUREMENT AND PROPAGATION EVENT SCHEDULE

FROM 563.50000 DAYS TO 570.00000 DAYS IN INCREMENTS OF .50000 DAYS -- CODE NO. 1212
FROM 564.00000 DAYS TO 570.00000 DAYS IN INCREMENTS OF 1.00000 DAYS -- CODE NO. 2202
FROM 564.00000 DAYS TO 570.00000 DAYS IN INCREMENTS OF 1.00000 DAYS -- CODE NO. 2121
FROM 563.50000 DAYS TO 570.00000 DAYS IN INCREMENTS OF .50000 DAYS -- CODE NO. 4123

0 EIGENVECTOR EVENTS

1 THRUST EVENTS

EVENT TIME (DAYS)	TYPE
567.000	0

1 GUIDANCE EVENTS

EVENT TIME (DAYS)	CUTOFF TIME (DAYS)	GUIDANCE DELAY TIME (DAYS)	GUIDANCE POLICY	READ CONTROL
566.500	587.000	.500	1	0
570.000	570.000	0.000	0	0

0 PREDICTION EVENTS

FILTERING ALGORITHM IS KALMAN-SCHMIDT

MEASUREMENT WHITE NOISE STANDARD DEVIATIONS

DATA TYPE	STD DEV
2-WAY DOPPLER	.10000000E+01 MM/S PER 1 MIN SAMPLE AT 12.0000 COUNTS/DAY
2-WAY RANGE	.30000000E+01 METERS
3-WAY DOPPLER	.10000000E+00 MM/S (FREQ DRIFT)
3-WAY RANGE	.10000000E+02 METERS
AZIMUTH	.16000000E+04 MICRO-RADIANS
ELEVATION	.16000000E+04 MICRO-RADIANS
STAR-PLANET ANGLE	.15000000E+03 MICRO-RADIANS
PLANET LIMB ANGLE	.15000000E+03 MICRO-RADIANS
CENTER-FINDING	.10000000E+02 KILOMETERS
BODY RT-ASCENSION	.30000000E+01 ARC-SECONDS
BODY DECLINATION	.30000000E+01 ARC-SECONDS

TOLERANCE ON MESHING SCHEDULED TIME POINTS WITH THOSE AVAILABLE ON STM FILE = .300E-01 DAYS
TOLERANCE ON MESHING SCHEDULED TIME POINTS WITH THOSE AVAILABLE ON STM FILE = .100E+01 DAYS
FAILURE TO MESH WITHIN TOLERANCE IS FATAL
CONTROL IS PROPAGATED SIMULTANEOUSLY WITH KNOWLEDGE
INITIAL TRAJECTORY TIME 563.0000 DAYS
FINAL TRAJECTORY TIME 570.0000 DAYS

PRINT CONTROL

0	0	0	0	0	0	0	0	0	0	0	0	0

STATION LOCATION COORDINATES

	SPIN RADIUS	LONGITUDE	Z-HEIGHT	LATITUDE
1	5200.234	243.167	3693.429	35.384
2	4855.414	356.333	4134.766	40.417
3	5204.135	149.136	-3686.233	-35.311

EQUIVALENT STATION ERRORS (1 SIGMA)

SPIN RADIUS	1.500000	METERS
LONGITUDE	3.000000	METERS
Z-HEIGHT	10.000000	METERS
LONGITUDE CORRELATION	.930000	

DYNAMIC NOISE PARAMETERS

PROCESS	STD DEV		CORRELATION TIME	
MAGNITUDE 1	.350000E+01	PER CENT	.400000E+01	DAYS
CONE 1	.100000E-01	RADIANS	.100000E+01	DAYS
CLOCK 1	.100000E-01	RADIANS	.100000E+01	DAYS

A PRIORI KNOWLEDGE UNCERTAINTY AT TRAJECTORY TIME 503.0000 DAYS

RSS POSITION = .17320508E+05 KM
RSS VELOCITY = .86602540E+01 M/S

STATE PARAMETERS

STANDARD DEVIATIONS AND CORRELATION COEFFICIENTS

	STD DEV	X	Y	Z	VX	VY	VZ
X	.10000000E+05	1.00000000					
Y	.10000000E+05	0.00000000	1.00000000				
Z	.10000000E+05	0.00000000	0.00000000	1.00000000			
VX	.50000000E-02	0.00000000	0.00000000	0.00000000	1.00000000		
VY	.50000000E-02	0.00000000	0.00000000	0.00000000	0.00000000	1.00000000	
VZ	.50000000E-02	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	1.00000000
ACCPFO		0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
CONE		0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
CLOCK		0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
EPH X		0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
EPH Y		0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
EPH Z		0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
EPH VX		0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
EPH VY		0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
EPH VZ		0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
RS 1		0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
LON 1		0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
Z-HT 1		0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
RS 2		0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
LON 2		0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
Z-HT 2		0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
RS 3		0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
LON 3		0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
Z-HT 3		0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000

SOLVE-FOR PARAMETERS

ORIGINAL PAGE IS OF POOR QUALITY

STANDARD DEVIATIONS AND CORRELATION COEFFICIENTS

	STD DEV	ACCPRO EPH VX	CONE EPH VY	CLOCK EPH VZ	EPH X	EPH Y	EPH Z
ACCPRO	.22000000E-01	1.00000000					
CONE	.35000000E-01	0.00000000	1.00000000				
CLOCK	.35000000E-01	0.00000000	0.00000000	1.00000000			
EPH X	.30000000E+04	0.00000000	0.00000000	0.00000000	1.00000000		
EPH Y	.30000000E+04	0.00000000	0.00000000	0.00000000	0.00000000	1.00000000	
EPH Z	.30000000E+04	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	1.00000000
EPH VX	.10000000E-02	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
		1.00000000					
EPH VY	.10000000E-02	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
		0.00000000	1.00000000				
EPH VZ	.10000000E-02	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
		0.00000000	0.00000000	1.00000000			
RS 1		0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
		0.00000000	0.00000000	0.00000000			
LON 1		0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
		0.00000000	0.00000000	0.00000000			
Z-HT 1		0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
		0.00000000	0.00000000	0.00000000			
RS 2		0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
		0.00000000	0.00000000	0.00000000			
LON 2		0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
		0.00000000	0.00000000	0.00000000			
Z-HT 2		0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
		0.00000000	0.00000000	0.00000000			
RS 3		0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
		0.00000000	0.00000000	0.00000000			
LON 3		0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
		0.00000000	0.00000000	0.00000000			
Z-HT 3		0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
		0.00000000	0.00000000	0.00000000			

MEASUREMENT PARAMETERS

STANDARD DEVIATIONS AND CORRELATION COEFFICIENTS

	STD DEV	RS 1 RS 3	LON 1 LON 3	Z-HT 1 Z-HT 3	RS 2	LON 2	Z-HT 2
RS 1	.15000000E-02	1.00000000					
LON 1	.57689712E-06	0.00000000	1.00000000				
Z-HT 1	.10000000E-01	0.00000000	0.00000000	1.00000000			
RS 2	.15000000E-02	0.00000000	0.00000000	0.00000000	1.00000000		
LON 2	.61726698E-06	0.00000000	.90000000	0.00000000	0.00000000	1.00000000	
Z-HT 2	.10000000E-01	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	1.00000000
RS 3	.15000000E-02	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
		1.00000000					
LON 3	.57646468E-06	0.00000000	.90000000	0.00000000	0.00000000	.90000000	0.00000000
		0.00000000	1.00000000				
Z-HT 3	.10000000E-01	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
		0.00000000	0.00000000	1.00000000			

INITIAL S/C MASS ERROR 0.0000 KG

JOB NO.
RUN DATE 08/30/74

SCHEDULED TRAJECTORY TIME 566.5000 DAYS
STM FILE TRAJECTORY TIME 566.5000 DAYS

GUIDANCE

JULIAN DATE -- 2444523.15478000	CONTROL PHASE -- 6	PRIMARY BODY -- SUN
DAYS FROM LAUNCH- 566.50000000	PRESENT S/C MASS- 1494.88289798 KG	EPHEMERIS BODY -- ENCKE
DAYS FROM CUTOFF- 3.50000000	POWER AVAILABLE-- 16.53524068 KW	TARGET BODY -- ENCKE

S/C RELATIVE STATES		X	Y	Z	MAGNITUDE
SUN	POSITION	.14320068295158E+09	.96710610715841E+08	.30214306629729E+08	.17542030141334E+09
	VELOCITY	-.26741573660874E+02	.37014455328659E+01	-.12933623814313E+01	.29015501292413E+02
EARTH	POSITION	.76632549044037E+06	.51811508340884E+08	.30214306629729E+08	.59982766413677E+08
	VELOCITY	-.19299782577011E+02	-.24540611042354E+02	-.12933623814313E+01	.31247335632346E+02
ENCKE	POSITION	-.60402073960085E+07	-.52375715164671E+07	-.29589034520448E+07	.85247504605956E+07
	VELOCITY	.34394298681177E+01	.26199926505304E+01	.14534680041873E+01	.45614261526117E+01

S/C ACCELERATIONS	X	Y	Z	MAGNITUDE
PRIMARY BODY	-.35220054555521E-05	-.23776416193867E-05	-.74282224472570E-06	.43127285253392E-05
PERTURBING BODIES	-.18687350356417E-10	-.10231041607534E-09	-.56491223272148E-10	.11835496021560E-09
THRUST	-.56394419340935E-07	-.64332293121060E-06	-.90769935048982E-07	.65213754974895E-06
RADIATION PRESSURE	0.	0.	0.	0.

EFFECTIVE S/C MASS STANDARD DEVIATIONS (KG)
CONTROL= .5958 KNOWLEDGE= 52.9512

JULIAN DATE -- 2444523.65478000	CONTROL PHASE -- 6	PRIMARY BODY -- SUN
DAYS FROM LAUNCH- 567.00000000	PRESENT S/C MASS- 1493.44517362 KG	EPHEMERIS BODY -- ENCKE
DAYS FROM CUTOFF- 26.50100000	POWER AVAILABLE-- 16.67711498 KW	TARGET BODY -- ENCKE

S/C RELATIVE STATES		X	Y	Z	MAGNITUDE
SUN	POSITION	.14195570116864E+09	.96870273013787E+08	.30157652201133E+08	.17448425394548E+09
	VELOCITY	-.28896603752137E+02	.36298841939673E+01	-.13296283225169E+01	.29154026695018E+02
EARTH	POSITION	-.65464338142395E+05	.50750238386279E+08	.30157652201133E+08	.59034523527578E+08
	VELOCITY	-.19209939603951E+02	-.24593819437732E+02	-.13296283225169E+01	.31235326884782E+02
ENCKE	POSITION	-.58519821312990E+07	-.51251724620792E+07	-.28962294488790E+07	.83289249744703E+07
	VELOCITY	.34229230657206E+01	.25635233467855E+01	.14480813295247E+01	.45263599872465E+01

S/C ACCELERATIONS	X	Y	Z	MAGNITUDE
PRIMARY BODY	-.35464671686104E-05	-.24201017644247E-05	-.75342635145977E-06	.43591252268340E-05
PERTURBING BODIES	-.17083525365332E-10	-.10512255121954E-09	-.59146242940511E-10	.12182313272852E-09
THRUST	-.53753040404846E-07	-.64970297816979E-06	-.91886732135804E-07	.65836655501630E-06
RADIATION PRESSURE	0.	0.	0.	0.

JULIAN DATE -- 2444543.65478000 | CONTROL PHASE -- 8 | PRIMARY BODY -- SUN
DAYS FROM LAUNCH- 587.00000000 | PRESENT S/C MASS- 1443.42139371 KG | EPHEMERIS BODY -- ENCKE
DAYS FROM CUTOFF- 6.50100000 | POWER AVAILABLE-- 21.00000000 KW | TARGET BODY -- ENCKE

S/C RELATIVE STATES		X	Y	Z	MAGNITUDE
SUN	POSITION	.85359276259084E+08	.98241654970290E+08	.26258480826740E+08	.13276722724417E+09
	VELOCITY	-.37310345962450E+02	-.25999227481589E+01	-.34069595598151E+01	.37287700628992E+02
EARTH	POSITION	-.31639687506246E+08	.70521286902571E+07	.26258480826740E+08	.41868914899812E+08
	VELOCITY	-.18231410837993E+02	-.26401752831425E+02	-.34069595598151E+01	.32265217605922E+02
ENCKE	POSITION	-.11641869300323E+07	-.11084388569942E+07	-.64249593206823E+06	.17311178268612E+07
	VELOCITY	.20823536042919E+01	.20012306653047E+01	.11469962073356E+01	.31875265392436E+01

S/C ACCELERATIONS	X	Y	Z	MAGNITUDE
PRIMARY BODY	-.48404963285670E-05	-.55710215812125E-05	-.14890482394648E-05	.75288744472E326E-05
PERTURBING BODIES	.16059975559255E-09	-.50006646228704E-10	-.14435848025030E-09	.22165610831511E-09
THRUST	-.55115136581322E-06	-.26362513750265E-06	-.16570613571341E-06	.63302869145735E-06
RADIATION PRESSURE	0.	0.	0.	0.

S/C MASS= .149345E+04 THRUST= .658367E-06 AT TIME 567.0000

S/C MASS= .144342E+04 THRUST= .633028E-06 AT TIME 567.0000

JULIAN DATE -- 2444550.15478000 | CONTROL PHASE -- 9 | PRIMARY BODY -- SUN
DAYS FROM LAUNCH- 593.50000000 | PRESENT S/C MASS- 1443.42139371 KG | EPHEMERIS BODY -- ENCKE
DAYS FROM CUTOFF- .00100000 | POWER AVAILABLE-- 21.00000000 KW | TARGET BODY -- ENCKE

S/C RELATIVE STATES		X	Y	Z	MAGNITUDE
SUN	POSITION	.63788094552524E+08	.95572648950013E+08	.24087262868869E+08	.11740208033284E+09
	VELOCITY	-.39847194934075E+02	-.67163684880397E+01	-.43706737542881E+01	.40644942352615E+02
EARTH	POSITION	-.42137162427563E+08	-.81485781646185E+07	.24087262868869E+08	.49215210670.5E+08
	VELOCITY	-.18519887852660E+02	-.27891846716592E+02	-.43706737542881E+01	.33764539807305E+02
ENCKE	POSITION	-.74088842535019E+04	-.21607795476913E+04	-.77279658567905E+03	.77578163193753E+04
	VELOCITY	.20482411951477E+01	.19519505693896E+01	.11402315985148E+01	.30505224721045E+01

S/C ACCELERATIONS	X	Y	Z	MAGNITUDE
PRIMARY BODY	-.52314740899675E-05	-.78382312592807E-05	-.19754766540795E-05	.96285356331469E-05
PERTURBING BODIES	.12951377523410E-09	.14737641084744E-10	-.81533760577229E-10	.15374904927835E-09
THRUST	0.	0.	0.	0.
RADIATION PRESSURE	0.	0.	0.	0.

UNWEIGHTED SENSITIVITY MATRIX (CUTOFF WRT CONTROLS)

-.72857199627BE+06	.12605052800AE+06	-.95229578597E+05	0.
-.160927437297E+06	-.807420516111E+06	.118593248094E+05	0.
-.202638116143E+06	.552072868530E+05	.365231655306E+06	0.
-.946565884279E+03	.203132601988E+00	-.111410052547E+00	-.551151365813E-06
-.281669221582E+00	-.906940344607E+00	.108740739237E-01	-.263625137503E-06
-.253970091301E+00	.756042323079E-01	.412889027565E+00	-.165706135713E-06

KNOWLEDGE COVARIANCE AT MANEUVER EXECUTION TIME 567.0000 DAYS
BASED ON MEASUREMENTS UP TO 566.5000 DAYS

RSS POSITION = .20746733E+03 KM
RSS VELOCITY = .12863454E+01 M/S

STATE PARAMETERS

STANDARD DEVIATIONS AND CORRELATION COEFFICIENTS

	STD DEV	X	Y	Z	VX	VY	VZ
X	.48925167E+02	1.00000000					
Y	.10291952E+03	-.83443262	1.00000000				
Z	.17336838E+03	.83458317	-.99999987	1.00000000			
VX	.50692387E-03	.71656680	-.58757729	.58753891	1.00000000		
VY	.61577030E-03	-.65721765	.76225247	-.76218586	-.85707312	1.00000000	
VZ	.10015685E-02	.64758525	-.74025175	.74018973	.86317727	-.99929273	1.00000000
ACCPFC		.49353771	-.38250367	.38262769	.84114825	-.72799167	.74212475
CONE		-.49642126	.33328819	-.33320734	-.88132628	.65957616	-.67184413
CLOCK		-.43926803	.27350989	-.27358211	-.78732471	.61503079	-.63160912
EPH X		.00335698	-.00158728	.00158917	-.00082434	.00181281	-.00189074
EPH Y		-.02397325	.02407533	-.02408043	-.00405731	.00335509	-.00241332
EPH Z		.05465395	-.05942885	.05943797	.01124137	-.01040086	.00500865
EPH VX		-.00108694	.00265805	-.00265695	-.00243320	.00397431	-.00394660
EPH VY		-.00479673	.00629611	-.00629585	-.00324583	.00534428	-.00520763
EPH VZ		.01037195	-.01615628	.01615355	.01063301	-.01749130	.01721461
RS 1		.20521900	-.00737462	.00750761	-.01699597	.00372125	.00198274
LON 1		.07150932	.04529250	-.04516438	.01004003	-.00757529	.01358030
Z-HT 1		-.34982835	.35082885	-.35087849	-.02184661	-.00502296	.02065211
RS 2		.07332713	-.03249132	.03252367	.00104080	.00514338	-.00549267
LON 2		.02532737	.03221255	-.03211917	.01230731	-.00777578	.01137876
Z-HT 2		.34290209	-.34662919	.34676978	.02164865	.01287751	-.02866563
RS 3		0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
LON 3		.04587001	.03671292	-.03660611	.01089348	-.00727156	.01182271
Z-HT 3		0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000

SOLVE-FOR PARAMETERS

STANDARD DEVIATIONS AND CORRELATION COEFFICIENTS

	STD DEV	ACCPRO EPH VX	CONE EPH VY	CLOCK EPH VZ	EPH X	EPH Y	EPH Z
ACCPRO	.54492807E-02	1.00000000					
CONE	.13518733E-01	-.91387515	1.00000000				
CLOCK	.17571955E-01	-.98704162	.90805097	1.00000000			
EPH X	.21721319E+04	-.00342609	.00027635	.00002916	1.00000000		
EPH Y	.19066017E+04	-.00222374	.00212760	.00203888	.93767799	1.00000000	
EPH Z	.11519611E+04	.00558232	-.00522117	-.00471068	.90017333	.81665764	1.00000000
EPH VX	.98778338E-03	-.00211928	.00180037	.00140582	.15013636	.07494941	.06979367
		1.00000000					
EPH VY	.99076961E-03	-.00052065	.00017040	-.00051647	.06090219	.14403249	.05453313
		.02341483	1.00000000				
EPH VZ	.98144045E-03	.00519497	-.00392801	-.00191077	.02896769	.02752334	.16761368
		.02399236	-.00394547	1.00000000			
RS 1		.00170995	.00042472	.00143224	.00263002	-.00303845	-.00161779
		-.00023506	.00015510	.00027850			
LON 1		.00266921	-.00260210	-.00246091	.00069757	.00205288	-.00886034
		-.00004810	-.00000075	.00019343			
Z-HT 1		-.00221248	.00487981	.00790155	-.00345338	.02175388	-.05122977
		-.00073460	.00086910	.00031945			
RS 2		-.00096018	.00027767	-.00084216	.00080114	-.00265753	.00481145
		.00011482	-.00006533	-.00014035			
LON 2		.00198069	-.00237912	-.00244853	.00010849	.00193791	-.00613814
		.00002057	-.00005876	.00011842			
Z-HT 2		-.00773520	.00527352	.00182901	.00344813	-.02172954	.05120941
		.00075848	-.00085835	-.00038374			
RS 3		0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
		0.00000000	0.00000000	0.00000000			
LON 3		.00220259	-.00235953	-.00232553	.00038182	.00189038	-.00710454
		-.00001285	-.00002819	.00014770			
Z-HT 3		0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
		0.00000000	0.00000000	0.00000000			

S/C UNCERTAINTY RELATIVE TO EPHEMERIS BODY

NDARD DEVIATIONS AND CORRELATION COEFFICIENTS

	STD DEV	X	Y	Z	VX	VY	VZ
X	.21725186E+04	1.00000000					
Y	.19069017E+04	.93697483	1.00000000				
Z	.11546990E+04	.69923450	.81330443	1.00000000			
VX	.11113616E-02	.14117582	.05386206	.09736148	1.00000000		
VY	.11637339E-02	.34314260	.14231026	-.30793878	-.18974760	1.00000000	
VZ	.13901517E-02	.03215163	-.00700270	.19065394	.29782450	-.37360029	1.00000000

POSITION SUB-BLOCK

E-VALS (SQRT)	EIGENVECTORS		
.362588E+04	.71129916	.61223945	.34527722
.380361E+03	-.65479985	.39860137	.64214804
.623553E+03	.25552039	-.68284684	.68441912

E-VALS (SQRT)	EIGENVECTORS		
.102114E-02	.82669766	.56071059	-.04663270
.977595E-03	-.41985466	.66994536	.61226693
.156456E-02	.37455712	-.48659722	.78925922

CONTROL COVARIANCE AT MANEUVER EXECUTION TIME 567.0000 DAYS

RSS POSITION = .17598913E+05 KM
RSS VELOCITY = .99443770E+01 M/S

STATE PARAMETERS

STANDARD DEVIATIONS AND CORRELATION COEFFICIENTS

	STD DEV	X	Y	Z	VX	VY	VZ
X	.10176128E+05	1.00000000					
Y	.10164129E+05	.00388754	1.00000000				
Z	.10141925E+05	.00133380	.00090343	1.00000000			
VX	.59093829E-02	.18520546	.01854794	.00726983	1.00000000		
VY	.57527098E-02	.02130342	.17423578	.00038405	-.00274082	1.00000000	
VZ	.55566318E-02	.00816420	.00357848	.15524781	.01510980	.00856908	1.00000000

	X	Y	Z	VX	VY	VZ
ACCPRC	-.00353684	-.03254264	-.00455641	-.03366138	-.33725808	-.04893756
CONE	-.05182933	.00639089	-.00560667	-.52362701	.06251509	-.00038707
CLOCK	.00490854	.00503213	-.03992697	.04948112	.05261599	-.42698147
EPH X	-.00000000	-.00000000	-.00000000	-.00000000	-.00000000	-.00000000
EPH Y	-.00000000	-.00000000	-.00000000	-.00000000	-.00000000	-.00000000
EPH Z	-.00000000	-.00000000	.00000000	-.00000000	-.00000000	.00000000
EPH VX	-.00000000	-.00000000	-.00000000	-.00000000	-.00000000	-.00000000
EPH VY	-.00000000	-.00000000	-.00000000	-.00000000	-.00000000	-.00000000
EPH VZ	-.00000000	-.00000000	.00000000	-.00000000	-.00000000	.00000000
RS 1	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
LON 1	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
Z-HT 1	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
RS 2	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
LON 2	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
Z-HT 2	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
RS 3	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
LON 3	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
Z-HT 3	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000

SOLVE-FOR PARAMETERS

ORIGINAL PAGE IS
OF POOR QUALITY

STANDARD DEVIATIONS AND CORRELATION COEFFICIENTS

	STD DEV	ACCPRO EPH VX	CONE EPH VY	CLOCK EPH VZ	EPH X	EPH Y	EPH Z
ACCPRO	.22300000E-01	1.00000000					
CONE	.35000000E-01	0.00000000	1.00000000				
CLOCK	.35000000E-01	0.00000000	0.00000000	1.00000000			
EPH X	.30234955E+04	0.00000000	0.00000000	0.00000000	1.00000000		
EPH Y	.30193969E+04	0.00000000	0.00000000	0.00000000	.00311871	1.00000000	
EPH Z	.30166430E+04	0.00000000	0.00000000	0.00000000	.00103348	.00067847	1.00000000
EPH VX	.10019073E-02	0.00000000	0.00000000	0.00000000	.13550119	.02820338	.00929324
		1.00000000					
EPH VY	.10003019E-02	0.00000000	0.00000000	0.00000000	.02821301	.11215739	.00618555
		.00392470	1.00000000				
EPH VZ	.99912232E-03	0.00000000	0.00000000	0.00000000	.00929853	.00618736	.09561429
		.00128764	.00086627	1.00000000			
RS 1		0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
		0.00000000	0.00000000	0.00000000			
LON 1		0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
		0.00000000	0.00000000	0.00000000			
Z-HT 1		0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
		0.00000000	0.00000000	0.00000000			
RS 2		0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
		0.00000000	0.00000000	0.00000000			
LON 2		0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
		0.00000000	0.00000000	0.00000000			
Z-HT 2		0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
		0.00000000	0.00000000	0.00000000			
RS 3		0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
		0.00000000	0.00000000	0.00000000			
LON 3		0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
		0.00000000	0.00000000	0.00000000			
Z-HT 3		0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
		0.00000000	0.00000000	0.00000000			

S/C UNCERTAINTY RELATIVE TO EPHEMERIS BODY

STANDARD DEVIATIONS AND CORRELATION COEFFICIENTS

	STD DEV	X	Y	Z	VX	VY	VZ
X	.10615795E+05	1.00000000					
Y	.13603126E+05	.00382518	1.00000000				
Z	.13561057E+05	.00130941	.00088516	1.00000000			
VX	.59937154E-02	.18148805	.01887236	.00731296	1.00000000		
VY	.58390302E-02	.02149578	.17002430	.00633076	-.00254592	1.00000000	
VZ	.56457419E-02	.00817122	.00368799	.15128016	.01470016	.00835481	1.00000000

POSITION SUB-BLOCK

E-VALS (SQRT)	EIGENVECTORS		
.105321E+05	.79573644	.58364946	.16173070
.105882E+05	-.58592470	.80945869	-.03832601
.105797E+05	-.15328328	-.06426461	.98609041

E-VALS (SQRT)	EIGENVECTORS		
.599887E-02	.99256136	-.02962352	.11808639
.584188E-02	.01479304	.99210416	.12454116
.563731E-02	-.12084335	-.12186789	.98516248

TARGET WRT BURN START STATE

VMAT

.106897718214E+01	.145576056845E+00	.392573933375E-01	.233362973725E+07	.131066234074E+06	.349750693240E+05
.144252931047E+00	.102432104766E+01	.415050403810E-01	.130424388194E+06	.232535214707E+07	.283763066629E+05
.423921540814E-01	.400653380134E-01	.903970457793E+00	.366492399923E+05	.375260818930E+05	.220491818387E+07

TARGET WRT CONTRL

SMAT

-.132527064858E+07	.226463559822E+06	-.156079400340E+06	-.310451491957E+00
-.329810266537E+06	-.135556516362E+07	.185071253656E+05	-.150173454620E+00
-.347652940952E+06	.591893753054E+05	.592781036278E+06	-.934161635121E-01

CONTROL WEIGHTS

ACCPPC	.1000E+01
CONE	.1000E+01
CLOCK	.1000E+01
CUTOFF	.1000E+01

TARGET WEIGHTS

X	.1000E+01
Y	.1000E+01
Z	.1000E+01

UNWEIGHTED GUIDANCE MATRIX (CONTROLS WRT TARGETS)

.642633145124E-06	.110399695622E-06	.157186700147E-06
-.163850121914E-06	.732789424044E-06	-.681392175036E-07
.427186629068E-06	-.429277148513E-07	-.157237563469E-05
.135865514806E+00	.629626561760E-01	.697598783173E-01

ORIGINAL PAGE IS OF POOR QUALITY

UNCONSTRAINED CONTROL CORRECTIONS

STANDARD DEVIATIONS AND CORRELATION COEFFICIENTS

	STD DEV	ACCPRO	CONE	CLOCK	CUTOFF
ACCPRO	.13675503E-01	1.00000000			
CONE	.13046915E-01	.08236106	1.00000000		
CLOCK	.27214157E-01	.02683697	-.01146795	1.00000000	
CUTOFF	.35065954E+04	.96746350	.26569853	-.14732920	1.00000000

ACCPRO, SIGMA= .13676E-01, MAX ALLOWED= .50000E+00
CONE, SIGMA= .13047E-01, MAX ALLOWED= .87266E+00
CLOCK, SIGMA= .27214E-01, MAX ALLOWED= .87266E+00
CUTOFF, SIGMA= .35066E+04, MAX ALLOWED= .43200E+07

RESID TARGET ERROR

STANDARD DEVIATIONS AND CORRELATION COEFFICIENTS

	STD DEV	X	Y	Z
X	.31045846E-09	1.00000000		
Y	.29551625E-09	.10385197	1.00000000	
Z	.23199113E-09	.87221179	.01988777	1.00000000

UNWEIGHTED GUIDANCE MATRIX (CONTROLS WRT TARGETS)

.64426321451246E-06	.11039969562E-06	.15718670014 7E-06
-.16886512191 4E-06	.70278942404 4E-06	-.66139217503 6E-07
.42718662906 9E-06	-.42927714851 3E-07	-.15723756346 9E-05
.13986551460 6E+00	.62962256176 0E-01	.69799878317 3E-01

FINAL CONTROL CORRECTIONS INCLUDING CONSTRAINTS

STANDARD DEVIATIONS AND CORRELATION COEFFICIENTS

	STD DEV	ACCPRO	CONE	CLOCK	CUTOFF
ACCPRO	.13675503E-01	1.00000000			
CONE	.13046915E-01	.08236106	1.00000000		
CLOCK	.27214157E-01	.02683697	-.01146795	1.00000000	
CUTOFF	.35065954E+04	.96746350	.26569853	-.14732920	1.00000000

CONTROL STANDARD DEVIATIONS AND MAXIMUM VALUES

ACCPRO	1.36755	50.00 PER CENT
CONE	.74753	50.00 DEGREES
CLOCK	1.55926	50.00 DEGREES
CUTOFF	.04059	50.00 DAYS

MASS STANDARD DEVIATION FOR GUIDANCE= .8677

GAMMA MATRIX

.70354912780 4E-06	.21293446941 7E-06	.17190237326 5E-06	.15198274034 6E+01	.34684427645 4E+00	.37329668479 1E+01
-.82316772262 7E-07	.69256998763 2E-06	-.39355544441 1E-07	-.30489337180 9E+00	.16095440380 2E+01	-.12917683172 1E+00
.38383392142 6E-06	-.44781378141 7E-07	-.14063926053 3E-05	.93367022800 7E+00	-.10283740801 3E+01	-.34536601533 9E+01
.16155455690 3E+00	.87651599789 6E-01	.71201051072 6E-01	.33716433029 7E+06	.16736133099 7E+06	.16121110121 2E+06

STATE ERROR AFTER BURN

CONTROL COVARIANCE AT MANEUVER EXECUTION TIME 567.0000 DAYS

STANDARD DEVIATIONS AND CORRELATION COEFFICIENTS

	STD DEV	X	Y	Z	VX	VY	VZ
X	.48925167E+02	1.00000000					
Y	.10291952E+03	-.83443202	1.00000000				
Z	.17336838E+03	.83458317	-.99999987	1.00000000			
VX	.50692387E-03	.71650680	-.58757729	.58753891	1.00000000		
VY	.61577033E-03	-.65721765	.76225247	-.76218586	-.85707312	1.00000000	
VZ	.10015685E-02	.64758525	-.74025175	.74018973	.86317727	-.99929273	1.00000000

TARGET ERROR BEFORE BURN

STANDARD DEVIATIONS AND CORRELATION COEFFICIENTS

	STD DEV	X	Y	Z
X	.19675628E+05	1.00000000		
Y	.18909759E+05	.19516883	1.00000000	
Z	.16833437E+05	.07080052	.06723815	1.00000000

TARGET ERROR AFTER BURN

STANDARD DEVIATIONS AND CORRELATION COEFFICIENTS

	STD DEV	X	Y	Z
X	.11773636E+04	1.00000000		
Y	.14091596E+04	-.82722541	1.00000000	
Z	.23178617E+04	.85100356	-.99846044	1.00000000

JOB NO.
RUN DATE 08/30/74

SCHEDULED TRAJECTORY TIME 567.0000 DAYS
STM FILE TRAJECTORY TIME 567.0000 DAYS

THRUST

JULIAN DATE -- 2444523.65478000		CONTROL PHASE -- 6		PRIMARY BODY -- SUN
DAYS FROM LAUNCH- 567.00000000		PRESENT S/C MASS- 1493.44517362 KG		EPHEMERIS BODY -- ENCKE
DAYS FROM CUTOFF- 3.00000000		POWER AVAILABLE-- 16.67711498 KW		TARGET BODY -- ENCKE

S/C RELATIVE STATES		X	Y	Z	MAGNITUDE
SUN	POSITION	.14195570119640E+09	.96870273018550E+08	.30157652204809E+08	.17445425399968E+09
	VELOCITY	-.26896610763889E+02	.36298841879293E+01	-.13296283251794E+01	.29154030706598E+02
EARTH	POSITION	-.65464360290527E+05	.50750238533478E+08	.30157652204809E+08	.59034523656024E+08
	VELOCITY	-.19209919644874E+02	-.24593819453643E+02	-.13296283251794E+01	.31235326922592E+02
ENCKE	POSITION	-.58919822733199E+07	-.51251724557176E+07	-.28962294595381E+07	.83289250721150E+07
	VELOCITY	.34229230373464E+01	.25855233288804E+01	.14480813231459E+01	.45263599535289E+01

S/C ACCELERATIONS	X	Y	Z	MAGNITUDE
PRIMARY BODY	-.35464671678281E-05	-.24201017634615E-05	-.75342665123834E-06	.43591292256246E-05
PERTURBING BODIES	-.17083525327899E-10	-.10512255084064E-09	-.59146242561655E-10	.12182313221238E-09
THRUST	-.53753040446822E-07	-.64970297804152E-06	-.91886732114227E-07	.65836655487341E-06
RADIATION PRESSURE	0.	0.	0.	0.

EFFECTIVE S/C MASS STANDARD DEVIATIONS (KG)
CONTROL= .6457 KNOWLEDGE= 52.6428

KNOWLEDGE UNCERTAINTIES AT EVENT TIME 567.0000 DAYS

POSITION SUB-BLOCK

E-VALS (SQRT)	EIGENVECTORS		
.193584E+02	.97815610	.10718370	-.17810758
.690267E-02	-.00118391	.85967347	.51084257
.136227E+03	.20786835	-.49947291	.84102174

E-VALS (SQRT)	EIGENVECTORS		
.152395E-03	.92795366	.21754630	-.30261463
.159051E-04	-.02654203	.84847505	.52856940
.764922E-03	.37174928	-.48245590	.79311964

RSS POSITION = .13759578E+03 KM
RSS VELOCITY = .78011673E+00 M/S

ORIGINAL PAGE IS OF POOR QUALITY

STATE PARAMETERS

STANDARD DEVIATIONS AND CORRELATION COEFFICIENTS

	STD DEV	X	Y	Z	VX	VY	VZ
X	.34065020E+02	1.00000000					
Y	.68073425E+02	-.81394355	1.00000000				
Z	.11462191E+03	.81417594	-.99999991	1.00000000			
VX	.31758237E-03	.37073228	-.33903035	.33907790	1.00000000		
VY	.37077274E-03	-.29597493	.45784281	-.45776822	-.85143707	1.00000000	
VZ	.60848265E-03	.27516471	-.41478870	.41472052	.85895893	-.99864503	1.00000000
ACCPRC		.19260718	-.14756884	.14760823	.86381476	-.66859607	.68107051
CONE		-.17218760	.12583559	-.12587485	-.62909630	.62077170	-.63308823
CLOCK		-.18273599	.09179895	-.09186573	-.62873668	.57258896	-.58091125
EPH X		.00564825	-.00383537	.00383724	-.00362317	.00176580	-.00193064
EPH Y		-.02635399	.02911683	-.02912060	-.00397792	-.00132226	.00279408
EPH Z		.06243197	-.06953678	.06954218	.00279683	.00271450	-.00640527
EPH VX		.00118906	.00041295	-.00041161	-.00164181	.00353836	-.00352349
EPH VY		-.00360835	.00505322	-.00505273	-.00233773	.00472872	-.00455541
EPH VZ		.00367985	-.00937415	.00937094	.00750313	-.01559198	.01534058
RS 1		.29509026	-.01173729	.01192471	-.02678965	.00558601	.00375519
LON 1		.10333245	.06853779	-.06841832	.01696079	-.01312073	.02274111
Z-HT 1		-.49276857	.52593661	-.52598304	-.02171469	-.01590625	.04298519
RS 2		.10517563	-.04882430	.04887715	.00155807	.00872338	-.00927601
LON 2		.33689027	.04878064	-.04871643	.02145719	-.01343723	.01902525
Z-HT 2		.49581765	-.52485167	.52498924	.02348044	.01777499	-.04469942
RS 3		0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
LON 3		.06642129	.05557186	-.05548488	.01819799	-.01258009	.01978406
Z-HT 3		0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000

SOLVE-FOR PARAMETERS

STANDARD DEVIATIONS AND CORRELATION COEFFICIENTS

	STD DEV	ACCPRO	CONE	CLOCK	EPH X	EPH Y	EPH Z	EPH VX	EPH VY	EPH VZ
ACCPRC	.41640616E-02	1.00000000								
CONE	.10814265E-01	-.91680762	1.00000000							
CLOCK	.13661145E-01	-.99785133	.91771351	1.00000000						
EPH X	.21665530E+04	-.00037653	.00024410	.00004825	1.00000000					
EPH Y	.19589513E+04	.00018759	.00000939	.00028163	.94775200	1.00000000				
EPH Z	.11361232E+04	-.00076458	.00027591	-.00033499	.91467210	.84371450	1.00000000			
EPH VX	.96094705E-03	-.00172745	.00144431	.00113295	.14329953	.08000805	.07508606	1.00000000		
EPH VY	.98587672E-03	.00076222	-.00132345	-.00155417	.06800496	.13766438	.06232587	.03336027	1.00000000	
EPH VZ	.97254322E-03	.00216751	-.00112046	.00046017	.03397563	.03293323	.15194468	.03534483	-.00557982	1.00000000

RS 1	.00227939	.00645132	.00187168	.00255337	-.00302951	-.00154538
	-.00038507	.00024071	.00042553			
LON 1	.00437310	-.00406476	-.00415027	.00070203	.00197365	-.00878548
	-.00007720	-.00004598	.00033227			
Z-HT 1	.00584338	-.00249974	.00139106	-.00365275	.02162783	-.05159141
	-.00110391	.00104237	.00073927			
RS 2	-.00121110	.00032192	-.00117245	.00082224	-.00263412	.00476675
	.00016366	-.00006436	-.00025934			
LON 2	.00336714	-.00367799	-.00402000	.00013408	.00185742	-.00666126
	.00003480	-.00012528	.00020949			
Z-HT 2	-.00636031	.00292387	-.00161662	.00366443	-.02183417	.05161520
	.00114577	-.00104915	-.00081213			
RS 3	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000			
LON 3	.00366643	-.00366762	-.00387013	.00039605	.00181472	-.00703267
	-.00002008	-.00008112	.00025662			
Z-HT 3	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000			

S/C UNCERTAINTY RELATIVE TO EPHEMERIS BODY

STANDARD DEVIATIONS AND CORRELATION COEFFICIENTS

	STD DEV	X	Y	Z	VX	VY	VZ
X	.21666284E+04	1.00000000					
Y	.16981892E+04	.94822302	1.00000000				
Z	.11339320E+04	.91633331	.84750255	1.00000000			
VX	.10315710E-02	.13823128	.07271330	.08126816	1.00000000		
VY	.10516503E-02	.06151733	.13519154	.04174655	-.06317827	1.00000000	
VZ	.11392693E-02	.03229487	.01897411	.15496842	.16950370	-.18554008	1.00000000

POSITION SUB-BLOCK

E-VALS (SQRT)	EIGENVECTORS		
.202531E+04	.71360296	.61292954	.34548635
.346879E+03	-.65281440	.39120250	.64868634
.557106E+03	.26244390	-.68645689	.67811888

E-VALS (SQRT)	EIGENVECTORS		
.100779E-02	.69065953	.71936966	.07952726
.958481E-03	-.60198788	.50948905	.61484266
.123843E-02	.40178089	-.47215274	.78462979

JOB NO.
RUN DATE 08/30/74

SCHEDULED TRAJECTORY TIME 570.0000 DAYS
STM FILE TRAJECTORY TIME 570.0000 DAYS

MEASUREMENT CODE = 4123
3 STAR-PLANETANGLES

MEASUREMENT WITH STARS 3 2 1

S/C DECLINATION = 56.9368 DEG.

S/C LONGITUDE = 21.2515 DEG.

ORIGINAL PAGE IS OF POOR QUALITY

JULIAN DATE -- 2444526.65478000		CONTROL PHASE -- 7		PRIMARY BODY -- SUN	
DAYS FROM LAUNCH- 570.00000000		PRESENT S/C MASS- 1486.88205628 KG		EPHEMERIS BODY -- ENCKE	
DAYS FROM CUTOFF- 0.00000000		POWER AVAILABLE-- 17.57595163 KW		TARGET BODY -- ENCKE	

S/C RELATIVE STATES		X	Y	Z	MAGNITUDE
SUN	POSITION	.13432886695046E+09	.97725402433980E+08	.29783037654459E+08	.16678456903[illegible]E+09
	VELOCITY	-.29961970610346E+02	.29556322918217E+01	-.15642448852830E+01	.30148316686363E+02
EARTH	POSITION	-.45924233755846E+07	.44354565032980E+08	.29783037654459E+08	.53656932735873E+08
	VELOCITY	-.18819671212259E+02	-.24753295547318E+02	-.15642448852830E+01	.31134426653367E+02
ENCKE	POSITION	-.50315712305555E+07	-.44636709060583E+07	-.25259258628199E+07	.71848012125918E+07
	VELOCITY	.32157884220742E+01	.25197705447185E+01	.14088496909091E+01	.43215039309425E+01

S/C ACCELERATIONS	X	Y	Z	MAGNITUDE
PRIMARY BODY	-.37088286804267E-05	-.26982082791724E-05	-.82231269226497E-06	.46596068785263E-05
PERTURBING BODIES	-.38895665213965E-11	-.12232523313180E-09	-.77784080272292E-10	.14501363567706E-09
THRUST	-.49664697092981E-06	-.54207825345629E-07	-.12221028913914E-06	.51432679963871E-06
RADIATION PRESSURE	0.	0.	0.	0.

KNOWLEDGE COVARIANCE BEFORE THE MEASUREMENT AT 570.00000 DAYS

RSS POSITION = .11569008E+03 KM
RSS VELOCITY = .36528141E+00 M/S

STATE PARAMETERS

STANDARD DEVIATIONS AND CORRELATION COEFFICIENTS

	STD DEV	X	Y	Z	VX	VY	VZ
X	.34611336E+02	1.00000000					
Y	.59174063E+02	-.86444197	1.00000000				
Z	.93191633E+02	.87976630	-.99950921	1.00000000			
VX	.22575338E-03	.28537631	-.18643022	.19406523	1.00000000		
VY	.15374511E-03	-.25899775	.35601015	-.35276748	-.52269463	1.00000000	
VZ	.24254559E-03	.21923315	-.25788357	.25749636	.64081186	-.98299512	1.00000000

ACCPRO	-.05858053	-.00523426	.00130066	-.39901352	.33995375	-.38951255
CONE	.06515052	-.04764553	.44910789	.42925455	-.50694624	.54265490
CLOCK	.07787766	-.01968211	.02346048	.43561747	-.41252281	.46085870
EPH X	.00678119	-.00603726	.00613180	-.00052759	.00169555	-.00218895
EPH Y	-.02722935	.02892089	-.02904608	-.00061031	-.00165431	.00436713
EPH Z	.05923867	-.06647934	.16655828	.00184274	.00446997	-.01090453
EPH VX	.00438798	-.00413091	.00417995	-.00056558	.00224197	-.00257487
EPH VY	-.00822494	.01001585	-.00998347	-.00557141	.01358889	-.01258351
EPH VZ	.00562036	-.00929294	.00913683	.01149051	-.02988927	.02879376
RS 1	.22904839	-.00922637	.02298843	-.03134601	.00086353	.01344464
LON 1	.15110624	.06254711	-.04972037	.02751323	-.02372785	.05172731
Z-HT 1	-.53176172	.57178111	-.57377517	-.00693918	-.06195031	.11535642
RS 2	.10643010	-.04057557	.04500944	-.00263542	.02769527	-.02432032
LON 2	.09518342	.03523854	-.03116182	.03210626	-.02341961	.04269869
Z-HT 2	.53355881	-.57091977	.57323463	.01381921	.06173490	-.11376937
RS 3	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
LON 3	.11666352	.04821426	-.03831261	.02824081	-.02232353	.04472810
Z-HT 3	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000

SOLVE-FOR PARAMETERS

STANDARD DEVIATIONS AND CORRELATION COEFFICIENTS

	STD DEV	ACCPRO EPH VX	CONE EPH VY	CLOCK EPH VZ	EPH X	EPH Y	EPH Z
ACCPRO	.23823819E-02	1.00000000					
CONE	.31665290E-02	-.97711481	1.00000000				
CLOCK	.79162058E-02	-.99353091	.98887315	1.00000000			
EPH X	.21857813E+04	.00035681	-.00090540	-.00062861	1.00000000		
EPH Y	.19258705E+04	-.00035896	.00139423	.00079485	.96325775	1.00000000	
EPH Z	.11366196E+04	.00037141	-.00316747	-.00152443	.93007769	.89491119	1.00000000
EPH VX	.92772638E-03	.00014075	-.00105749	-.00063711	.24192476	.14374880	.14072852
		1.00000000					
EPH VY	.94247822E-03	.00031833	-.00278367	-.00131223	.14429147	.25642197	.12789315
		.13630926	1.00000000				
EPH VZ	.89501276E-03	-.00024530	.00725710	.00368949	.08250655	.07334051	.28067418
		.13219986	-.00264537	1.00000000			
RS 1		.00193134	.01474638	.01555217	.00186547	-.00284174	-.00094836
		-.00170467	.00108524	.00158782			
LON 1		.00166131	-.00427175	-.00143550	.00077088	.00133553	-.00736823
		-.00005187	-.00083847	.00183622			
Z-HT 1		-.00397292	.03112354	.02402587	-.00495304	.02113717	-.04862452
		-.00368671	.00153798	.00532728			
RS 2		.00005705	-.00980811	-.00417380	.00093372	-.00234980	.00397504
		.00043478	.00012795	-.00115808			
LON 2		.00102149	-.00659976	-.00228415	.00037760	.00122781	-.00491081
		.00040032	-.00106603	.00127663			
Z-HT 2		-.00353030	-.02752916	-.00994500	.00495925	-.02113164	.04862566
		.00372058	-.00153640	-.00539980			
RS 3		0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
		0.00000000	0.00000000	0.00000000			
LON 3		.00127080	-.00514966	-.00176194	.00054402	.00121422	-.00581639
		.00016505	-.00090213	.00147451			
Z-HT 3		0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
		0.00000000	0.00000000	0.00000000			

S/C UNCERTAINTY RELATIVE TO EPHEMERIS BODY

STANDARD DEVIATIONS AND CORRELATION COEFFICIENTS

	STD DEV	X	Y	Z	VX	VY	VZ
X	.21858200E+04	1.00000000					
Y	.19250680E+04	.96383810	1.00000000				
Z	.11342349E+04	.93171725	.89907755	1.00000000			
VX	.95492377E-03	.23615573	.13862580	.14000719	1.00000000		
VY	.95287179E-03	.14190856	.25545894	.12217610	.11199592	1.00000000	
VZ	.92652975E-03	.08161709	.06837518	.28119145	.162[illegible]882	-.03636580	1.00000000

POSITION SUB-BLOCK

E-VALS (SQRT)	EIGENVECTORS		
.307527E+04	.70618967	.61670178	.34781470
.235612E+03	-.66676108	.41440758	.61969943
.447531E+03	.23817182	-.66953464	.70356062

E-VALS (SQRT)	EIGENVECTORS		
.102727E-02	.77231434	.43338535	.46494193
.957946E-03	-.10455756	.80812225	-.57966037
.833236E-03	-.62694623	.39889293	.66919568

OBSERVATION MATRIX

X	-.943111973E-07	-.991865639E-07	.995679187E-09
Y	.589626728E-07	.886687274E-07	-.693938479E-07
Z	.836697319E-07	.408864900E-07	.120645453E-06
VX	0.	0.	0.
VY	0.	0.	0.
VZ	0.	0.	0.
ACCPPC	0.	0.	0.
CONE	0.	0.	0.
CLOCK	0.	0.	0.
EPH X	.943111973E-07	.991865639E-07	-.995679187E-09
EPH Y	-.589626728E-07	-.886687274E-07	.693938479E-07
EPH Z	-.836697319E-07	-.408864900E-07	-.120645453E-06
EPH VX	-0.	-0.	-0.
EPH VY	-0.	-0.	-0.
EPH VZ	-0.	-0.	-0.
PS 1	0.	0.	0.
LON 1	0.	0.	0.
Z-HT 1	0.	0.	0.
PS 2	0.	0.	0.
LON 2	0.	0.	0.
Z-HT 2	0.	0.	0.
PS 3	0.	0.	0.
LON 3	0.	0.	0.
Z-HT 3	0.	0.	0.

MEAS NOISE

.225019371823E-07	0.	0.
0.	.225019371823E-07	0.
0.	0.	.225019371823E-07

H*P*HT + R

.246562183175E-07	.205457818416E-08	.631484391909E-09
.205457818416E-08	.249537783955E-07	-.772538053018E-09
.631484391909E-09	-.772538053018E-09	.262015302638E-07

GAIN MATRIX

X	-.713753675E+03	-.160571606E+04	.221340133E+04
Y	.652601345E+03	.274138193E+04	-.530841935E+04
Z	-.109174821E+04	-.435184496E+04	.827620876E+04
VX	-.224662746E-02	-.110130540E-01	.223394143E-01
VY	-.337769961E-02	.105812741E-01	-.364256362E-01
VZ	.469667434E-02	-.165390870E-01	.553599976E-01
ACCPFC	.232207943E-01	.265511095E-01	-.573986237E-02
CONE	-.367121939E-02	-.672940820E-01	.163681088E+00
CLOCK	-.621222316E-01	-.141792612E+00	.197902058E+00
EPH X	.676500801E+06	.735362298E+06	-.687730107E+05
EPH Y	-.546323674E+04	-.241872724E+06	.649209606E+06
EPH Z	-.212263864E+06	.862462108E+05	-.790156920E+06
EPH VX	.696794433E+00	.735602330E+00	-.145474508E-01
EPH VY	-.401964538E+00	-.644260516E+00	.575704166E+00
EPH VZ	-.605777909E+00	-.256983517E+00	-.974197742E+00

KNOWLEDGE COVARIANCE AFTER THE MEASUREMENT AT 570.00000 DAYS

RSS POSITION = .11567480E+03 KM
RSS VELOCITY = .36508400E+00 M/S.

STATE PARAMETERS

STANDARD DEVIATIONS AND CORRELATION COEFFICIENTS

	STD DEV	X	Y	Z	VX	VY	VZ
X	.34608252E+02	1.00000000					
Y	.59165935E+02	-.86442125	1.00000000				
Z	.93176968E+02	.87974846	-.99950910	1.00000000			
VX	.22571651E-03	.28521366	-.18618678	.19382548	1.00000000		
VY	.15362003E-03	-.25875531	.35573557	-.35246465	-.52249902	1.00000000	
VZ	.24236186E-03	.21895659	-.25749182	.25710899	.64071870	-.98296947	1.00000000
ACCPFC		-.05856241	-.00525767	.00132375	-.39305616	.34020112	-.38977905
CONE		.06504321	-.04750388	.04890742	.42917831	-.50701600	.54273698
CLOCK		.07781638	-.01960079	.02337997	.43560311	-.41267831	.46103388
EPH X		.00745135	-.00664792	.00675102	.00008512	.00104822	-.00153510
EPH Y		-.02797069	.02988127	-.03000041	-.00160901	.00056336	.00223046
EPH Z		.06085215	-.06867612	.06873611	.00375472	-.00017024	-.00649114
EPH VX		.00592542	-.00548065	.00555210	.00073864	.00110493	-.00140865
EPH VY		-.01050319	.01264119	-.01259845	-.00830982	.01872892	-.01758314
EPH VZ		.00688808	-.01158309	.01138121	.01410566	-.03745411	.03603141

RS 1	.22907830	-.00923393	.02299609	-.03134505	.00086766	.01345223
LON 1	.15105199	.06259355	-.04976464	.02747610	-.02363038	.05167291
Z-HT 1	-.53183350	.57190614	-.57389864	-.00699312	-.06184281	.11529296
RS 2	.10645080	-.04059767	.04503188	-.00261753	.02767191	-.02429461
LON 2	.09510420	.03927998	-.03120186	.03207209	-.02335145	.04264675
Z-HT 2	.53363104	-.57104528	.57335860	.01387493	.06162517	-.11370275
RS 3	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
LON 3	.11664767	.04825588	-.03835255	.02820704	-.02225441	.04467773
Z-HT 3	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000

SOLVE-FOR PARAMETERS

STANDARD DEVIATIONS AND CORRELATION COEFFICIENTS

	STD DEV	ACCPRO / EPH VX	CONE / EPH VY	CLOCK / EPH VZ	EPH X	EPH Y	EPH Z
ACCPRO	.23823747E-02	1.00000000					
CONE	.31603973E-02	-.97714840	1.00000000				
CLOCK	.73160992E-02	-.99353822	.98888277	1.00000000			
EPH X	.21795999E+04	.00017319	-.00065879	-.00038001	1.00000000		
EPH Y	.19229049E+04	-.00030026	.00088926	.00052445	.96892770	1.00000000	
EPH Z	.11286068E+04	.00035416	-.00218536	-.00107046	.93958298	.90881282	1.00000000
EPH VX	.91272512E-03	-.00329985	-.00056031	-.00008422	.23289944	.14930036	.14586115
		1.00000000					
EPH VY	.92945582E-03	.00038058	-.00406765	-.00216916	.15718103	.25280989	.14146273
		.16473821	1.00000000				
EPH VZ	.67434083E-03	-.00005441	.00876234	.00422569	.09214382	.08346044	.26574654
		.15750653	.00202783	1.00000000			
RS 1		.00192747	.01475058	.00555587	.00174829	-.00283807	-.00089675
		-.00233256	.00126340	.00187279			
LON 1		.00166288	-.00429347	-.00144634	.00080414	.00120602	-.00713887
		-.00000188	-.00113217	.00230161			
Z-HT 1		-.00397816	.03105443	.01401638	-.00516095	.02098084	-.04841572
		-.00426130	.00148296	.00659973			
RS 2		.00005702	-.00979875	-.00416946	.00094403	-.00229350	.00386127
		.00047248	.00022813	-.00142713			
LON 2		.00102395	-.00662003	-.00229498	.00043952	.00110810	-.00470545
		.00053298	-.00138582	.00162403			
Z-HT 2		-.00352500	-.02749951	-.03993534	.00517004	-.02097308	.04840955
		.00430324	-.00148090	-.00668949			
RS 3		0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
		0.00000000	0.00000000	0.00000000			
LON 3		.00127271	-.00516955	-.00177220	.00058910	.00109616	-.00561047
		.00025157	-.00119273	.00185951			
Z-HT 3		0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
		0.00000000	0.00000000	0.00000000			

S/C UNCERTAINTY RELATIVE TO EPHEMERIS BODY

STANDARD DEVIATIONS AND CORRELATION COEFFICIENTS

	STD DEV	X	Y	Z	VX	VY	VZ

ORIGINAL PAGE IS
OF POOR QUALITY

X	.21796168E+04	1.00000000					
Y	.19220470E+04	.96957913	1.00000000				
Z	.11260456E+04	.94134161	.91334295	1.00000000			
VX	.94005690E-03	.22710133	.14419807	.14444351	1.00000000		
VY	.93922249E-03	.15486694	.25160663	.13659920	.13956417	1.00000000	
VZ	.89695513E-03	.05087505	.07882844	.26566155	.18731137	-.03074781	1.00000000

POSITION SUB-BLOCK

E-VALS (SQRT)	EIGENVECTORS		
.307385E+04	.70522544	.61748553	.34838011
.307713E+03	-.67082764	.42213094	.60975057
.411952E+03	.22945013	-.66371462	.71192383

E-VALS (SQRT)	EIGENVECTORS		
.102626E-02	.75926045	.48029324	.43913776
.937761E-03	-.14494705	.78263412	-.60537111
.800745E-03	-.63443985	.39598262	.66384023

JOB NO.
RUN DATE 08/30/74

SCHEDULED TRAJECTORY TIME 570.0000 DAYS
STM FILE TRAJECTORY TIME 570.0000 DAYS

GUIDANCE

JULIAN DATE -- 2444526.65476000	CONTROL PHASE -- 7		PRIMARY BODY -- SUN
DAYS FROM LAUNCH- 570.00000000	PRESENT S/C MASS- 1486.88205628 KG		EPHEMERIS BODY -- ENCKE
DAYS FROM CUTOFF- 0.00000000	POWER AVAILABLE-- 17.57595163 KW		TARGET BODY -- ENCKE

S/C RELATIVE STATES		X	Y	Z	MAGNITUDE
SUN	POSITION	.134328868982504E+09	.977254024339800E+08	.297830376544590E+08	.168784569030166E+09
	VELOCITY	-.299619706103460E+02	.295563229182170E+01	-.156424488528330E+01	.301483166863600E+02
EARTH	POSITION	-.459924233755846E+07	.443545650329800E+08	.297830376544590E+08	.535593327358730E+08
	VELOCITY	-.188196712122590E+02	-.247532554730820E+02	-.156424488528300E+01	.311344266588670E+02
ENCKE	POSITION	-.503157123055550E+07	-.446367090805830E+07	-.252592586281990E+07	.712480121299180E+07
	VELOCITY	.321578842207420E+01	.251977054471850E+01	.140884969090910E+01	.432150393054250E+01

S/C ACCELERATIONS	X	Y	Z	MAGNITUDE
PRIMARY BODY	-.370882868042670E-05	-.269820827917240E-05	-.822312692264970E-06	.465960687852630E-05
PERTURBING BODIES	-.388956652139650E-11	-.122325233131800E-09	-.777840802722920E-10	.145013835677060E-09
THRUST	-.498046970929810E-06	-.542078253456290E-07	-.122210289109140E-06	.514326799638710E-06
RADIATION PRESSURE	0.	0.	0.	0.

EFFECTIVE S/C MASS STANDARD DEVIATIONS (KG)
CONTROL= .7896 KNOWLEDGE= 52.1613

KNOWLEDGE COVARIANCE AT MANEUVER EXECUTION TIME 570.0000 DAYS
BASED ON MEASUREMENTS UP TO 570.0000 DAYS

RSS POSITION = .11567480E+03 KM
RSS VELOCITY = .36508400E+00 M/S

STATE PARAMETERS

STANDARD DEVIATIONS AND CORRELATION COEFFICIENTS

	STD DEV	X	Y	Z	VX	VY	VZ
X	.34608252E+02	1.00000000					
Y	.59165935E+02	-.86442125	1.00000000				
Z	.93178968E+02	.87974846	-.99950910	1.00000000			
VX	.22571651E-03	.28521368	-.18618678	.19382548	1.00000000		
VY	.15362003E-03	-.25875531	.35570557	-.35246465	-.52249902	1.00000000	
VZ	.24236186E-03	.21895695	-.25749182	.25710899	.64071870	-.98296947	1.00000000

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ORIGINAL PAGE IS
OF POOR QUALITY

ACCPFC	-.05856241	-.00525767	.00132375	-.39305616	.34020112	-.38977905
CONE	.06504381	-.04750388	.04896742	.42917831	-.50701600	.54273698
CLOCK	.07781638	-.01960079	.02337597	.43560311	-.41267831	.46103388
EPH X	.00745135	-.00664792	.00675102	.00008512	.00104822	-.00153510
EPH Y	-.02797069	.02988127	-.03000041	-.00160901	.00056336	.00223046
EPH Z	.06085215	-.06867612	.06873611	.00375472	-.00017024	-.00649114
EPH VX	.00592542	-.00548065	.00555210	.00073664	.00110493	-.00140865
EPH VY	-.01050319	.01263119	-.01259845	-.00830982	.01872892	-.01753314
EPH VZ	.00688808	-.01158309	.01138121	.01410566	-.03745411	.03603141
RS 1	.22907830	-.00923393	.02299609	-.03134505	.00086766	.01345223
LON 1	.15109199	.06259355	-.04976464	.02747610	-.02363008	.05167291
Z-HT 1	-.53183350	.57193614	-.57389864	-.00599312	-.06184281	.11529296
RS 2	.10645380	-.04059767	.04503188	-.00261753	.02767191	-.02429461
LON 2	.09516420	.03927598	-.03120186	.03207209	-.02335145	.04264675
Z-HT 2	.53363104	-.57104528	.57335860	.01387493	.06162517	-.11370275
RS 3	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
LON 3	.11664767	.04825588	-.03835255	.02820704	-.02225441	.04467773
Z-HT 3	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000

SOLVE-FOR PARAMETERS

STANDARD DEVIATIONS AND CORRELATION COEFFICIENTS

	STD DEV	ACCPRO EPH VX	CONE EPH VY	CLOCK EPH VZ	EPH X	EPH Y	EPH Z
ACCPFC	.23823747E-02	1.00000000					
CONE	.31603973E-02	-.97714840	1.00000000				
CLOCK	.79160992E-02	-.99353822	.98868277	1.00000000			
EPH X	.21799999E+04	.00017319	-.00065879	-.00038061	1.00000000		
EPH Y	.19229049E+04	-.00030026	.00088926	.00052445	.96892770	1.00000000	
EPH Z	.11286068E+04	.00035416	-.00218536	-.00107046	.93958298	.90881282	1.00000000
EPH VX	.91272512E-03	-.00029985	-.00056031	-.00008422	.23269944	.14930036	.14586115
		1.00000000					
EPH VY	.92945582E-03	.00036050	-.00406765	-.00216916	.15718103	.25280989	.14146273
		.16473821	1.00000000				
EPH VZ	.87434083E-03	-.00305441	.00876234	.00422589	.09214382	.08346044	.26574654
		.15750653	.00202783	1.00000000			
RS 1		.00192747	.01475058	.00555587	.00174829	-.00283807	-.00089675
		-.00203256	.00126040	.00187279			
LON 1		.00166288	-.00429347	-.00144634	.00080414	.00120602	-.00713287
		-.00000188	-.00113217	.00230161			
Z-HT 1		-.00097816	.03109443	.01401638	-.00516095	.02098084	-.04841572
		-.00426130	.00148296	.00659973			
RS 2		.00305732	-.00979875	-.00416946	.00394403	-.00229350	.00380127
		.00047248	.00022813	-.00142713			
LON 2		.00102395	-.00662003	-.00229498	.00343952	.00110810	-.00470545
		.00053298	-.00138582	.00162403			
Z-HT 2		-.00352500	-.02749951	-.00993534	.00517004	-.02097308	.04840955
		.00430324	-.00148090	-.00668949			
RS 3		0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
		0.00000000	0.00000000	0.00000000			
LON 3		.00127271	-.00016955	-.00177220	.00058910	.00109616	-.00561047
		.00025157	-.00119273	.00185951			
Z-HT 3		0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
		0.00000000	0.00000000	0.00000000			

S/C UNCERTAINTY RELATIVE TO EPHEMERIS BODY

ARD DEVIATIONS AND CORRELATION COEFFICIENTS

	STD DEV	X	Y	Z	VX	VY	VZ
X	.21796168E+04	1.00000000					
Y	.19220470E+04	.96957913	1.00000000				
Z	.11260456E+04	.94134161	.91334295	1.00000000			
VX	.94055859E-03	.22710133	.14419837	.14444351	1.00000000		
VY	.93922249E-03	.15486694	.25160663	.13659926	.13956417	1.00000000	
VZ	.89889513E-03	.09087565	.07882844	.26566155	.18731137	-.03074781	1.00000000

POSITION SUB-BLOCK

E-VALS (SQRT)	EIGENVECTORS		
.307385E+04	.70522544	.61748553	.34838011
.307713E+03	-.67082764	.42213094	.60975057
.411952E+03	.22945013	-.66371462	.71192383

E-VALS (SQRT)	EIGENVECTORS		
.102626E-02	.75926045	.48029324	.43913776
.937761E-03	-.14494705	.78263412	-.60537111
.800745E-03	-.63443985	.39598262	.66384023

CONTROL COVARIANCE AT MANEUVER EXECUTION TIME 570.0000 DAYS

RSS POSITION = .65917015E+03 KM
RSS VELOCITY = .19754803E+01 M/S

STATE PARAMETERS

STANDARD DEVIATIONS AND CORRELATION COEFFICIENTS

	STD DEV	X	Y	Z	VX	VY	VZ
X	.31557503E+03	1.00000000					
Y	.35615267E+03	-.29385130	1.00000000				
Z	.45615016E+03	.65385048	-.65889987	1.00000000			
VX	.14503063E-02	.84646615	-.09892783	.37275626	1.00000000		
VY	.96045319E-03	.04202085	.87731729	-.23654325	.12272709	1.00000000	
VZ	.93630324E-03	.70913371	-.54636646	.92893988	.56322409	-.22455980	1.00000000
ACCPRO		.56506551	-.42995652	.65824744	.28201079	-.07580606	.54502598
CONE		-.60787719	.39551112	-.59218841	-.31774911	-.03422046	-.48768936
CLOCK		-.53099487	.33972259	-.54441937	-.26541145	.03573191	-.42630826
EPH X		-.00009457	.00082685	-.00111730	-.00034746	.00125190	-.00242889
EPH Y		-.00601958	.00894004	-.01128483	-.00150170	.00165308	-.00279120
EPH Z		.01506120	-.02389550	.03021142	.00437799	-.00627778	.01091755
EPH VX		-.00153560	.00279293	-.00373589	-.00078768	.00178040	-.00382358
EPH VY		-.00225069	.00454704	-.00574405	-.00103529	.00335159	-.00560528
EPH VZ		.00687955	-.01235279	.01729082	.00336794	-.00946324	.01754045
RS 1		.02334157	-.00030805	.03407977	-.00629689	.00210294	.00224545
LON 1		.01623207	.00933423	-.00807378	.00353209	-.00068104	.01397363
Z-HT 1		-.06556598	.35809371	-.11975583	-.00817046	-.03597934	.02410018
RS 2		.01192904	-.00667556	.01875489	.00053868	.00326377	-.00597213
LON 2		.01050210	.00545546	-.01457134	.00462209	-.00387978	.01164625
Z-HT 2		.05855252	-.05357852	.11267205	.00459764	.00647384	-.03025508
RS 3		0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
LON 3		.01266356	.00700565	-.01598979	.00386250	-.00358144	.01213573
Z-HT 3		0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000

SOLVE-FOR PARAMETERS

STANDARD DEVIATIONS AND CORRELATION COEFFICIENTS

	STD DEV	ACCPFO / EPH VX	CONE / EPH VY	CLOCK / EPH VZ	EPH X	EPH Y	EPH Z
ACCPFO	.54492807E-02	1.00000000					
CONE	.13518733E-01	-.91387515	1.00000000				
CLOCK	.17507195E-01	-.98704162	.90885097	1.00000000			
EPH X	.22415030E+04	-.00069706	.00050929	.00021694	1.00000000		
EPH Y	.19751446E+04	-.00222515	.00207905	.00188894	.90004804	1.00000000	
EPH Z	.12370346E+04	.00643812	-.00579842	-.00483992	.83087376	.75000717	1.00000000
EPH VX	.99309687E-03	-.00213510	.00181508	.00141889	.31171967	.10998727	.10310312
		1.00000000					
EPH VY	.99237176E-03	-.00051522	.00016329	-.00052618	.08510138	.31101353	.06970161
		.03387497	1.00000000				
EPH VZ	.97962388E-03	.00514543	-.00388166	-.00186880	.03561637	.03067114	.39801325
		.02730241	-.00151559	1.00000000			
RS 1		.00170995	.00042472	.00143224	.00251572	-.00290563	-.00143775
		-.00025744	.00020624	.00029551			
LON 1		.00266921	-.00260210	-.00246091	.00067059	.00198088	-.00819548
		-.00003186	-.00000924	.00027163			
Z-HT 1		-.00221248	.00487981	.00790155	-.00343355	.02111448	-.04757850
		-.00050393	.00065470	.00076214			
RS 2		-.00096018	.00027767	-.00184216	.00079033	-.00257298	.00444212
		.00009413	-.00003545	-.00018136			
LON 2		.00196069	-.00237912	-.00244853	.00010891	.00186070	-.00568132
		.00003597	-.00007244	.00017224			
Z-HT 2		-.00773520	.00527352	.00182901	.00343166	-.02108967	.04754355
		.00058798	-.00064612	-.00082026			
RS 3		0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
		0.00000000	0.00000000	0.00000000			
LON 3		.00220299	-.00235953	-.00232553	.00036923	.00181970	-.00657322
		.00000194	-.00003869	.00021026			
Z-HT 3		0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
		0.00000000	0.00000000	0.00000000			

S/C UNCERTAINTY RELATIVE TO EPHEMERIS BODY

STANDARD DEVIATIONS AND CORRELATION COEFFICIENTS

	STD DEV	X	Y	Z	VX	VY	VZ
X	.22637172E+04	1.00000000					
Y	.20030620E+04	.87187587	1.00000000				
Z	.13054626E+04	.80972413	.66750672	1.00000000			
VX	.17583795E-02	.27206403	.04766663	.15831582	1.00000000		
VY	.13787252E-02	.06409793	.32755827	-.01661964	.08420053	1.00000000	
VZ	.13431864E-02	.09561019	-.04199385	.48971069	.33799881	-.10221181	1.00000000

POSITION SUB-BLOCK

E-VALS (SQRT)	EIGENVECTORS		
.310799E+04	.71371927	.60781314	.34809194
.595747E+03	-.65417187	.40382693	.64140253
.913830E+03	.25032826	-.68549323	.68369204

E-VALS (SQRT)	EIGENVECTORS		
.186559E-02	.93374703	.06611262	.42290076
.141707E-02	.11642251	.91279708	-.39146812
.114386E-02	-.41193095	.40302682	.81724065

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563.5000 BEFORE M=1212 P= .1732E+05 KM   STATE      .1000E+05  .1000E+05  .1000E+05  .5016E-02  .5061E-02  .5010E-02
                       V= .8711E+01 M/S SOLVE-FOR   .1200E-01  .3500E-01  .3500E-01  .3000E+04  .3000E+04  .3000E+04
                                                    .1000E-02  .1000E-02  .1000E-02
563.5000 AFTER  M=1212 P= .1400E+05 KM   STATE      .1549E+04  .9974E+04  .9632E+04  .4994E-02  .2557E-02  .4453E-02
                       V= .7163E+01 M/S SOLVE-FOR   .2198E-01  .3500E-01  .3499E-01  .3000E+04  .3000E+04  .3000E+04
                                                    .1000E-02  .1000E-02  .1000E-02
563.5000 BEFORE M=4123 P= .1400E+05 KM   STATE      .1549E+04  .9974E+04  .9632E+04  .4994E-02  .2557E-02  .4453E-02
                       V= .7163E+01 M/S SOLVE-FOR   .2198E-01  .3500E-01  .3499E-01  .3000E+04  .3000E+04  .3000E+04
                                                    .1000E-02  .1000E-02  .1000E-02
563.5000 AFTER  M=4123 P= .5532E+04 KM   STATE      .7345E+03  .4099E+04  .3641E+04  .4994E-02  .2399E-02  .4439E-02
                       V= .7099E+01 M/S SOLVE-FOR   .2196E-01  .3500E-01  .3499E-01  .2869E+04  .2886E+04  .2842E+04
                                                    .1000E-02  .1000E-02  .1000E-02
564.0000 BEFORE M=1212 P= .5539E+04 KM   STATE      .7590E+03  .4106E+04  .3640E+04  .5038E-02  .2531E-02  .4466E-02
                       V= .7193E+01 M/S SOLVE-FOR   .2198E-01  .3500E-01  .3499E-01  .2871E+04  .2887E+04  .2843E+04
                                                    .1000E-02  .1000E-02  .9999E-03
564.0000 AFTER  M=1212 P= .5416E+04 KM   STATE      .7208E+03  .3951E+04  .3634E+04  .1827E-02  .2451E-02  .4319E-02
                       V= .5292E+01 M/S SOLVE-FOR   .2099E-01  .3479E-01  .3465E-01  .2836E+04  .2843E+04  .2842E+04
                                                    .1000E-02  .1000E-02  .9999E-03
564.0000 BEFORE M=2002 P= .5416E+04 KM   STATE      .7208E+03  .3951E+04  .3634E+04  .1827E-02  .2451E-02  .4319E-02
                       V= .5292E+01 M/S SOLVE-FOR   .2099E-01  .3479E-01  .3465E-01  .2836E+04  .2843E+04  .2842E+04
                                                    .1000E-02  .1000E-02  .9999E-03
564.0000 AFTER  M=2002 P= .3266E+04 KM   STATE      .6014E+03  .1553E+04  .2810E+04  .1380E-02  .2451E-02  .4315E-02
                       V= .5151E+01 M/S SOLVE-FOR   .2099E-01  .3477E-01  .3465E-01  .2263E+04  .2499E+04  .2602E+04
                                                    .1000E-02  .1000E-02  .9999E-03
564.0000 BEFORE M=2121 P= .3266E+04 KM   STATE      .6014E+03  .1553E+04  .2810E+04  .1380E-02  .2451E-02  .4315E-02
                       V= .5151E+01 M/S SOLVE-FOR   .2099E-01  .3477E-01  .3465E-01  .2263E+04  .2499E+04  .2602E+04
                                                    .1000E-02  .1000E-02  .9999E-03
564.0000 AFTER  M=2121 P= .1734E+03 KM   STATE      .6441E+02  .7736E+02  .1412E+03  .1231E-02  .2408E-02  .4315E-02
                       V= .5093E+01 M/S SOLVE-FOR   .2099E-01  .3477E-01  .3465E-01  .2261E+04  .2148E+04  .1576E+04
                                                    .1000E-02  .1000E-02  .9999E-03
564.0000 BEFORE M=4123 P= .1734E+03 KM   STATE      .6441E+02  .7736E+02  .1412E+03  .1231E-02  .2408E-02  .4315E-02
                       V= .5093E+01 M/S SOLVE-FOR   .2099E-01  .3477E-01  .3465E-01  .2261E+04  .2148E+04  .1576E+04
                                                    .1000E-02  .1000E-02  .9999E-03
564.0000 AFTER  M=4123 P= .1733E+03 KM   STATE      .6430E+02  .7734E+02  .1411E+03  .1229E-02  .2400E-02  .4302E-02
                       V= .5077E+01 M/S SOLVE-FOR   .2099E-01  .3477E-01  .3465E-01  .2205E+04  .2014E+04  .1356E+04
                                                    .9998E-03  .9998E-03  .9996E-03
564.5000 BEFORE M=1212 P= .2918E+03 KM   STATE      .6090E+02  .1389E+03  .2493E+03  .1349E-02  .2542E-02  .4345E-02
                       V= .5211E+01 M/S SOLVE-FOR   .2099E-01  .3477E-01  .3465E-01  .2207E+04  .2016E+04  .1355E+04
                                                    .9999E-03  .9998E-03  .9995E-03
564.5000 AFTER  M=1212 P= .2864E+03 KM   STATE      .4128E+02  .1364E+03  .2484E+03  .1036E-02  .2457E-02  .4314E-02
                       V= .5072E+01 M/S SOLVE-FOR   .2017E-01  .3331E-01  .3426E-01  .2207E+04  .2016E+04  .1359E+04
                                                    .9999E-03  .9998E-03  .9995E-03
564.5000 BEFORE M=4123 P= .2864E+03 KM   STATE      .4128E+02  .1364E+03  .2484E+03  .1036E-02  .2457E-02  .4314E-02
                       V= .5072E+01 M/S SOLVE-FOR   .2017E-01  .3331E-01  .3426E-01  .2207E+04  .2016E+04  .1359E+04
                                                    .9999E-03  .9998E-03  .9995E-03
564.5000 AFTER  M=4123 P= .2836E+03 KM   STATE      .4123E+02  .1351E+03  .2480E+03  .1026E-02  .2424E-02  .4257E-02
                       V= .5005E+01 M/S SOLVE-FOR   .2017E-01  .3331E-01  .3425E-01  .2184E+04  .1960E+04  .1265E+04
                                                    .9992E-03  .9993E-03  .9985E-03
565.0000 BEFORE M=1212 P= .4762E+03 KM   STATE      .5933E+02  .2317E+03  .4117E+03  .1205E-02  .2573E-02  .4316E-02
                       V= .5167E+01 M/S SOLVE-FOR   .2017E-01  .3331E-01  .3425E-01  .2187E+04  .1962E+04  .1268E+04
                                                    .9994E-03  .9994E-03  .9985E-03
565.0000 AFTER  M=1212 P= .4656E+03 KM   STATE      .5071E+02  .2274E+03  .4032E+03  .1113E-02  .2455E-02  .4231E-02
                       V= .4991E+01 M/S SOLVE-FOR   .1347E-01  .2895E-01  .3345E-01  .2187E+04  .1962E+04  .1265E+04
                                                    .9994E-03  .9994E-03  .9985E-03
565.0000 BEFORE M=2002 P= .4656E+03 KM   STATE      .5071E+02  .2274E+03  .4032E+03  .1113E-02  .2455E-02  .4231E-02
                       V= .4991E+01 M/S SOLVE-FOR   .1347E-01  .2895E-01  .3345E-01  .2187E+04  .1962E+04  .1268E+04
                                                    .9994E-03  .9994E-03  .9985E-03
565.0000 AFTER  M=2002 P= .4571E+03 KM   STATE      .5053E+02  .2216E+03  .3966E+03  .1131E-02  .2396E-02  .4098E-02
                       V= .4873E+01 M/S SOLVE-FOR   .1949E-01  .2889E-01  .3080E-01  .2187E+04  .1962E+04  .1268E+04
                                                    .9994E-03  .9994E-03  .9985E-03
565.0000 BEFORE M=2121 P= .4571E+03 KM   STATE      .5053E+02  .2216E+03  .3966E+03  .1131E-02  .2396E-02  .4098E-02
                       V= .4873E+01 M/S SOLVE-FOR   .1149E-01  .2869E-01  .3080E-01  .2187E+04  .1962E+04  .1268E+04
                                                    .9994E-03  .9994E-03  .9985E-03
565.0000 AFTER  M=2121 P= .1588E+03 KM   STATE      .3569E+02  .7576E+02  .1349E+03  .5919E-03  .8817E-03  .1531E-02
                       V= .1863E+01 M/S SOLVE-FOR   .9483E-02  .2857E-01  .3077E-01  .2187E+04  .1962E+04  .1266E+04
                                                    .9994E-03  .9994E-03  .9985E-03
565.0000 BEFORE M=4123 P= .1588E+03 KM   STATE      .3569E+02  .7576E+02  .1349E+03  .5919E-03  .8817E-03  .1531E-02
                       V= .1863E+01 M/S SOLVE-FOR   .9483E-02  .2857E-01  .3077E-01  .2187E+04  .1962E+04  .1266E+04
                                                    .9994E-03  .9994E-03  .9985E-03
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ORIGINAL PAGE IS OF POOR QUALITY

565.0000	AFTER	M=4123	P=	.1586E+03	KM	STATE	.3569E-02	.7508E+02	.1348E+03	.5913E-03	.8788E-03	.1526E-02
			V=	.1658E+01	M/S	SOLVE-FOR	.9482E-02	.2857E-01	.3077E-01	.2175E+04	.1931E+04	.1212E+04
							.9971E-03	.9983E-03	.9965E-03			
565.5000	BEFORE	M=1212	P=	.2127E+03	KM	STATE	.5169E+02	.1060E+03	.1770E+03	.8580E-03	.1213E-02	.1601E-02
			V=	.2184E+01	M/S	SOLVE-FOR	.9482E-02	.2857E-01	.3077E-01	.2178E+04	.1935E+04	.1216E+04
							.9981E-03	.9984E-03	.9964E-03			
565.5000	AFTER	M=1212	P=	.2068E+03	KM	STATE	.3756E+02	.1006E+03	.1768E+03	.5849E-03	.9391E-03	.1595E-02
			V=	.1941E+01	M/S	SOLVE-FOR	.9334E-02	.2198E-01	.3049E-01	.2178E+04	.1935E+04	.1216E+04
							.9981E-03	.9984E-03	.9964E-03			
565.5000	BEFORE	M=4123	P=	.2068E+03	KM	STATE	.3756E+02	.1006E+03	.1768E+03	.5849E-03	.9391E-03	.1595E-02
			V=	.1941E+01	M/S	SOLVE-FOR	.9334E-02	.2198E-01	.3049E-01	.2178E+04	.1935E+04	.1216E+04
							.9981E-03	.9984E-03	.9964E-03			
565.5000	AFTER	M=4123	P=	.2061E+03	KM	STATE	.3754E+02	.1002E+03	.1761E+03	.5836E-03	.9337E-03	.1585E-02
			V=	.1930E+01	M/S	SOLVE-FOR	.9329E-02	.2198E-01	.3049E-01	.2169E+04	.1915E+04	.1181E+04
							.9956E-03	.9967E-03	.9933E-03			
566.0000	BEFORE	M=1212	P=	.2759E+03	KM	STATE	.5684E+02	.1380E+03	.2321E+03	.7910E-03	.1276E-02	.1696E-02
			V=	.2269E+01	M/S	SOLVE-FOR	.9329E-02	.2198E-01	.3049E-01	.2174E+04	.1919E+04	.1185E+04
							.9959E-03	.9968E-03	.9932E-03			
566.0000	AFTER	M=1212	P=	.2712E+03	KM	STATE	.4652E+02	.1337E+03	.2313E+03	.5850E-03	.1014E-02	.1682E-02
			V=	.2049E+01	M/S	SOLVE-FOR	.9204E-02	.1714E-01	.3015E-01	.2174E+04	.1919E+04	.1185E+04
							.9959E-03	.9968E-03	.9932E-03			
566.0000	BEFORE	M=2002	P=	.2712E+03	KM	STATE	.4652E+02	.1337E+03	.2313E+03	.5850E-03	.1014E-02	.1682E-02
			V=	.2049E+01	M/S	SOLVE-FOR	.9204E-02	.1714E-01	.3015E-01	.2174E+04	.1919E+04	.1185E+04
							.9959E-03	.9968E-03	.9932E-03			
566.0000	AFTER	M=2002	P=	.2692E+03	KM	STATE	.4600E+02	.1327E+03	.2297E+03	.5431E-03	.9702E-03	.1603E-02
			V=	.1951E+01	M/S	SOLVE-FOR	.6775E-02	.1654E-01	.2103E-01	.2174E+04	.1919E+04	.1185E+04
							.9959E-03	.9968E-03	.9932E-03			
566.0000	BEFORE	M=2121	P=	.2692E+03	KM	STATE	.4600E+02	.1327E+03	.2297E+03	.5431E-03	.9702E-03	.1603E-02
			V=	.1951E+01	M/S	SOLVE-FOR	.6775E-02	.1654E-01	.2103E-01	.2174E+04	.1919E+04	.1185E+04
							.9959E-03	.9968E-03	.9932E-03			
566.0000	AFTER	M=2121	P=	.1472E+03	KM	STATE	.3368E+02	.7177E+02	.1240E+03	.3586E-03	.5135E-03	.8593E-03
			V=	.1063E+01	M/S	SOLVE-FOR	.6307E-02	.1583E-01	.2071E-01	.2174E+04	.1919E+04	.1185E+04
							.9959E-03	.9968E-03	.9931E-03			
566.0000	BEFORE	M=4123	P=	.1472E+03	KM	STATE	.3368E+02	.7177E+02	.1240E+03	.3586E-03	.5135E-03	.8593E-03
			V=	.1063E+01	M/S	SOLVE-FOR	.6307E-02	.1583E-01	.2071E-01	.2174E+04	.1919E+04	.1185E+04
							.9959E-03	.9968E-03	.9931E-03			
566.0000	AFTER	M=4123	P=	.1471E+03	KM	STATE	.3368E+02	.7172E+02	.1239E+03	.3583E-03	.5125E-03	.8575E-03
			V=	.1061E+01	M/S	SOLVE-FOR	.6306E-02	.1583E-01	.2071E-01	.2167E+04	.1906E+04	.1159E+04
							.9921E-03	.9941E-03	.9883E-03			
566.5000	BEFORE	M=1212	P=	.1773E+03	KM	STATE	.4263E+02	.9184E+02	.1456E+03	.5024E-03	.9766E-03	.9648E-03
			V=	.1462E+01	M/S	SOLVE-FOR	.6306E-02	.1583E-01	.2071E-01	.2172E+04	.1911E+04	.1165E+04
							.9925E-03	.9943E-03	.9882E-03			
566.5000	AFTER	M=1212	P=	.1722E+03	KM	STATE	.3710E+02	.8594E+02	.1451E+03	.3958E-03	.5541E-03	.9114E-03
			V=	.1138E+01	M/S	SOLVE-FOR	.5452E-02	.1352E-01	.1751E-01	.2172E+04	.1911E+04	.1165E+04
							.9925E-03	.9943E-03	.9882E-03			
566.5000	BEFORE	M=4123	P=	.1722E+03	KM	STATE	.3710E+02	.8594E+02	.1451E+03	.3958E-03	.5541E-03	.9114E-03
			V=	.1138E+01	M/S	SOLVE-FOR	.5452E-02	.1352E-01	.1751E-01	.2172E+04	.1911E+04	.1165E+04
							.9925E-03	.9943E-03	.9882E-03			
566.5000	AFTER	M=4123	P=	.1719E+03	KM	STATE	.3708E+02	.8489E+02	.1448E+03	.3951E-03	.5523E-03	.9085E-03
			V=	.1134E+01	M/S	SOLVE-FOR	.5449E-02	.1352E-01	.1751E-01	.2166E+04	.1901E+04	.1146E+04
							.9873E-03	.9906E-03	.9815E-03			
567.0000	BEFORE	M=1212	P=	.2105E+03	KM	STATE	.4927E+02	.1085E+03	.1735E+03	.5243E-03	.1005E-02	.1012E-02
			V=	.1519E+01	M/S	SOLVE-FOR	.5449E-02	.1352E-01	.1751E-01	.2172E+04	.1907E+04	.1152E+04
							.9878E-03	.9908E-03	.9814E-03			
567.0000	AFTER	M=1212	P=	.2051E+03	KM	STATE	.4361E+02	.1024E+03	.1723E+03	.4188E-03	.5935E-03	.9582E-03
			V=	.1202E+01	M/S	SOLVE-FOR	.4777E-02	.1146E-01	.1504E-01	.2172E+04	.1907E+04	.1152E+04
							.9878E-03	.9908E-03	.9814E-03			
567.0000	BEFORE	M=2002	P=	.2051E+03	KM	STATE	.4361E+02	.1024E+03	.1723E+03	.4188E-03	.5935E-03	.9582E-03
			V=	.1202E+01	M/S	SOLVE-FOR	.4777E-02	.1146E-01	.1504E-01	.2172E+04	.1907E+04	.1152E+04
							.9878E-03	.9908E-03	.9814E-03			
567.0000	AFTER	M=2002	P=	.2048E+03	KM	STATE	.4356E+02	.1022E+03	.1720E+03	.4138E-03	.5837E-03	.9422E-03
			V=	.1183E+01	M/S	SOLVE-FOR	.4537E-02	.1145E-01	.1415E-01	.2172E+04	.1907E+04	.1152E+04
							.9878E-03	.9908E-03	.9814E-03			
567.0000	BEFORE	M=2121	P=	.2048E+03	KM	STATE	.4356E+02	.1022E+03	.1720E+03	.4138E-03	.5837E-03	.9422E-03
			V=	.1183E+01	M/S	SOLVE-FOR	.4537E-02	.1145E-01	.1415E-01	.2172E+04	.1907E+04	.1152E+04
							.9878E-03	.9908E-03	.9814E-03			

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567.0000 AFTER  M=2121 P= .1377E+03 KM         STATE   .3407E+02  .6811E+02  .1147E+03  .3178E-03  .3713E-03  .6094E-03
                       V= .7812E+00 M/S SOLVE-FOR      .4185E-02  .1082E-01  .1368E-01  .2172E+04  .1907E+04  .1152E+04
                                                       .9878E-03  .9908E-03  .9813E-03
567.0000 BEFORE M=4123 P= .1377E+03 KM         STATE   .3407E+02  .6811E+02  .1147E+03  .3178E-03  .3713E-03  .6094E-03
                       V= .7812E+00 M/S SOLVE-FOR      .4185E-02  .1082E-01  .1368E-01  .2172E+04  .1907E+04  .1152E+04
                                                       .9878E-03  .9908E-03  .9813E-03
567.0000 AFTER  M=4123 P= .1376E+03 KM         STATE   .3407E+02  .6807E+02  .1146E+03  .3176E-03  .3708E-03  .6085E-03
                       V= .7801E+00 M/S SOLVE-FOR      .4184E-02  .1081E-01  .1368E-01  .2167E+04  .1899E+04  .1136E+04
                                                       .9809E-03  .9859E-03  .9725E-03
567.5000 BEFORE M=1212 P= .1574E+03 KM         STATE   .4809E+02  .7723E+02  .1285E+03  .6408E-03  .3792E-03  .6382E-03
                       V= .9807E+00 M/S SOLVE-FOR      .4184E-02  .1081E-01  .1368E-01  .2173E+04  .1905E+04  .1143E+04
                                                       .9815E-03  .9861E-03  .9724E-03
567.5000 AFTER  M=1212 P= .1538E+03 KM         STATE   .3765E+02  .7704E+02  .1276E+03  .3310E-03  .3652E-03  .5857E-03
                       V= .7655E+00 M/S SOLVE-FOR      .3798E-02  .9888E-02  .1224E-01  .2173E+04  .1905E+04  .1143E+04
                                                       .9815E-03  .9861E-03  .9724E-03
567.5000 BEFORE M=4123 P= .1538E+03 KM         STATE   .3765E+02  .7704E+02  .1276E+03  .3310E-03  .3652E-03  .5857E-03
                       V= .7655E+00 M/S SOLVE-FOR      .3798E-02  .9888E-02  .1224E-01  .2173E+04  .1905E+04  .1143E+04
                                                       .9815E-03  .9861E-03  .9724E-03
567.5000 AFTER  M=4123 P= .1536E+03 KM         STATE   .3763E+02  .7695E+02  .1275E+03  .3308E-03  .3643E-03  .5843E-03
                       V= .7639E+00 M/S SOLVE-FOR      .3797E-02  .9884E-02  .1224E-01  .2168E+04  .1899E+04  .1130E+04
                                                       .9730E-03  .9799E-03  .9615E-03
568.0000 BEFORE M=1212 P= .1757E+03 KM         STATE   .5182E+02  .8725E+02  .1434E+03  .6309E-03  .3398E-03  .5699E-03
                       V= .9156E+00 M/S SOLVE-FOR      .3797E-02  .9884E-02  .1224E-01  .2175E+04  .1906E+04  .1138E+04
                                                       .9736E-03  .9801E-03  .9614E-03
568.0000 AFTER  M=1212 P= .1707E+03 KM         STATE   .4158E+02  .8662E+02  .1411E+03  .3326E-03  .3392E-03  .5255E-03
                       V= .7084E+00 M/S SOLVE-FOR      .3663E-02  .9288E-02  .1183E-01  .2175E+04  .1906E+04  .1138E+04
                                                       .9736E-03  .9801E-03  .9614E-03
568.0000 BEFORE M=2002 P= .1707E+03 KM         STATE   .4158E+02  .8662E+02  .1411E+03  .3326E-03  .3392E-03  .5255E-03
                       V= .7084E+00 M/S SOLVE-FOR      .3663E-02  .9288E-02  .1183E-01  .2175E+04  .1906E+04  .1138E+04
                                                       .9736E-03  .9801E-03  .9614E-03
568.0000 AFTER  M=2002 P= .1612E+03 KM         STATE   .4081E+02  .8108E+02  .1333E+03  .3301E-03  .2908E-03  .4547E-03
                       V= .6327E+00 M/S SOLVE-FOR      .2569E-02  .3436E-02  .8495E-02  .2175E+04  .1906E+04  .1138E+04
                                                       .9736E-03  .9801E-03  .9614E-03
568.0000 BEFORE M=2121 P= .1612E+03 KM         STATE   .4081E+02  .8108E+02  .1333E+03  .3301E-03  .2908E-03  .4547E-03
                       V= .6327E+00 M/S SOLVE-FOR      .2569E-02  .3436E-02  .8495E-02  .2175E+04  .1906E+04  .1138E+04
                                                       .9736E-03  .9801E-03  .9614E-03
568.0000 AFTER  M=2121 P= .1282E+03 KM         STATE   .3508E+02  .6405E+02  .1053E+03  .3053E-03  .2093E-03  .3329E-03
                       V= .4979E+00 M/S SOLVE-FOR      .2546E-02  .3412E-02  .8495E-02  .2175E+04  .1906E+04  .1138E+04
                                                       .9736E-03  .9801E-03  .9612E-03
568.0000 BEFORE M=4123 P= .1282E+03 KM         STATE   .3508E+02  .6405E+02  .1053E+03  .3053E-03  .2093E-03  .3329E-03
                       V= .4979E+00 M/S SOLVE-FOR      .2546E-02  .3412E-02  .8495E-02  .2175E+04  .1906E+04  .1138E+04
                                                       .9736E-03  .9801E-03  .9612E-03
568.0000 AFTER  M=4123 P= .1281E+03 KM         STATE   .3507E+02  .6404E+02  .1053E+03  .3052E-03  .2090E-03  .3325E-03
                       V= .4974E+00 M/S SOLVE-FOR      .2546E-02  .3412E-02  .8494E-02  .2169E+04  .1901E+04  .1127E+04
                                                       .9635E-03  .9725E-03  .9480E-03
568.5000 BEFORE M=1212 P= .1398E+03 KM         STATE   .4840E+02  .6874E+02  .1117E+03  .6262E-03  .2320E-03  .3580E-03
                       V= .7577E+00 M/S SOLVE-FOR      .2546E-02  .3412E-02  .8494E-02  .2177E+04  .1909E+04  .1135E+04
                                                       .9641E-03  .9728E-03  .9478E-03
568.5000 AFTER  M=1212 P= .1362E+03 KM         STATE   .3747E+02  .6861E+02  .1116E+03  .3215E-03  .2143E-03  .3352E-03
                       V= .5115E+00 M/S SOLVE-FOR      .2538E-02  .3319E-02  .8462E-02  .2177E+04  .1909E+04  .1135E+04
                                                       .9641E-03  .9728E-03  .9478E-03
568.5000 BEFORE M=4123 P= .1362E+03 KM         STATE   .3747E+02  .6861E+02  .1116E+03  .3215E-03  .2143E-03  .3352E-03
                       V= .5115E+00 M/S SOLVE-FOR      .2538E-02  .3319E-02  .8462E-02  .2177E+04  .1909E+04  .1135E+04
                                                       .9641E-03  .9728E-03  .9478E-03
568.5000 AFTER  M=4123 P= .1362E+03 KM         STATE   .3746E+02  .6858E+02  .1115E+03  .3214E-03  .2139E-03  .3347E-03
                       V= .5110E+00 M/S SOLVE-FOR      .2538E-02  .3319E-02  .8462E-02  .2171E+04  .1905E+04  .1125E+04
                                                       .9524E-03  .9637E-03  .9325E-03
569.0000 BEFORE M=1212 P= .1498E+03 KM         STATE   .5126E+02  .7421E+02  .1193E+03  .6395E-03  .2403E-03  .3655E-03
                       V= .7748E+00 M/S SOLVE-FOR      .2538E-02  .3319E-02  .8462E-02  .2180E+04  .1914E+04  .1135E+04
                                                       .9532E-03  .9640E-03  .9324E-03
569.0000 AFTER  M=1212 P= .1460E+03 KM         STATE   .4025E+02  .7414E+02  .1192E+03  .3346E-03  .2229E-03  .3427E-03
                       V= .5283E+00 M/S SOLVE-FOR      .2537E-02  .3315E-02  .8462E-02  .2180E+04  .1914E+04  .1135E+04
                                                       .9532E-03  .9640E-03  .9324E-03
569.0000 BEFORE M=2002 P= .1460E+03 KM         STATE   .4025E+02  .7414E+02  .1192E+03  .3346E-03  .2229E-03  .3427E-03
                       V= .5283E+00 M/S SOLVE-FOR      .2537E-02  .3315E-02  .8462E-02  .2180E+04  .1914E+04  .1135E+04
                                                       .9532E-03  .9640E-03  .9324E-03
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569.0000	AFTER	M=2002	P=	.1457E+03	KM	STATE	.3937E+02	.7414E+02	.1191E+03	.2347E-03	.2229E-03	.3407E-03
			V=	.4700E+00	M/S	SOLVE-FOR	.2524E-02	.3315E-02	.8413E-02	.2180E+04	.1914E+04	.1135E+04
							.9532E-03	.9640E-03	.9324E-03			
569.0000	BEFORE	M=2121	P=	.1457E+03	KM	STATE	.3937E+02	.7414E+02	.1191E+03	.2347E-03	.2229E-03	.3407E-03
			V=	.4700E+00	M/S	SOLVE-FOR	.2524E-02	.3315E-02	.8413E-02	.2180E+04	.1914E+04	.1135E+04
							.9532E-03	.9640E-03	.9324E-03			
569.0000	AFTER	M=2121	P=	.1215E+03	KM	STATE	.3470E+02	.6151E+02	.9891E+02	.2178E-03	.1688E-03	.2630E-03
			V=	.3809E+00	M/S	SOLVE-FOR	.2516E-02	.3296E-02	.8412E-02	.2180E+04	.1914E+04	.1134E+04
							.9532E-03	.9640E-03	.9321E-03			
569.0000	BEFORE	M=4123	P=	.1215E+03	KM	STATE	.3470E+02	.6151E+02	.9891E+02	.2178E-03	.1688E-03	.2630E-03
			V=	.3809E+00	M/S	SOLVE-FOR	.2516E-02	.3296E-02	.8412E-02	.2180E+04	.1914E+04	.1134E+04
							.9532E-03	.9640E-03	.9321E-03			
569.0000	AFTER	M=4123	P=	.1215E+03	KM	STATE	.3469E+02	.6150E+02	.9889E+02	.2178E-03	.1686E-03	.2627E-03
			V=	.3806E+00	M/S	SOLVE-FOR	.2515E-02	.3296E-02	.8412E-02	.2174E+04	.1910E+04	.1125E+04
							.9401E-03	.9535E-03	.9148E-03			
569.5000	BEFORE	M=1212	P=	.1304E+03	KM	STATE	.4574E+02	.6532E+02	.1023E+03	.5998E-03	.2029E-03	.3072E-03
			V=	.7038E+00	M/S	SOLVE-FOR	.2515E-02	.3296E-02	.8412E-02	.2180E+04	.1919E+04	.1135E+04
							.9410E-03	.9539E-03	.9146E-03			
569.5000	AFTER	M=1212	P=	.1275E+03	KM	STATE	.3716E+02	.6486E+02	.1032E+03	.3267E-03	.1796E-03	.2801E-03
			V=	.4663E+00	M/S	SOLVE-FOR	.2504E-02	.3295E-02	.8373E-02	.2183E+04	.1919E+04	.1135E+04
							.9410E-03	.9539E-03	.9146E-03			
569.5000	BEFORE	M=4123	P=	.1275E+03	KM	STATE	.3716E+02	.6486E+02	.1032E+03	.3267E-03	.1796E-03	.2801E-03
			V=	.4663E+00	M/S	SOLVE-FOR	.2504E-02	.3295E-02	.8373E-02	.2183E+04	.1919E+04	.1135E+04
							.9410E-03	.9539E-03	.9146E-03			
569.5000	AFTER	M=4123	P=	.1274E+03	KM	STATE	.3716E+02	.6484E+02	.1032E+03	.3266E-03	.1794E-03	.2797E-03
			V=	.4660E+00	M/S	SOLVE-FOR	.2504E-02	.3294E-02	.8373E-02	.2177E+04	.1916E+04	.1127E+04
							.9268E-03	.9421E-03	.8955E-03			
570.0000	BEFORE	M=1212	P=	.1387E+03	KM	STATE	.5094E+02	.6914E+02	.1089E+03	.6513E-03	.2160E-03	.3266E-03
			V=	.7599E+00	M/S	SOLVE-FOR	.2504E-02	.3294E-02	.8373E-02	.2186E+04	.1926E+04	.1137E+04
							.9277E-03	.9426E-03	.8953E-03			
570.0000	AFTER	M=1212	P=	.1348E+03	KM	STATE	.3987E+02	.6905E+02	.1087E+03	.3393E-03	.1942E-03	.2987E-03
			V=	.4908E+00	M/S	SOLVE-FOR	.2502E-02	.3293E-02	.8365E-02	.2186E+04	.1926E+04	.1137E+04
							.9277E-03	.9426E-03	.8953E-03			
570.0000	BEFORE	M=2002	P=	.1348E+03	KM	STATE	.3987E+02	.6905E+02	.1087E+03	.3393E-03	.1942E-03	.2987E-03
			V=	.4908E+00	M/S	SOLVE-FOR	.2502E-02	.3293E-02	.8365E-02	.2186E+04	.1926E+04	.1137E+04
							.9277E-03	.9426E-03	.8953E-03			
570.0000	AFTER	M=2002	P=	.1344E+03	KM	STATE	.3865E+02	.6905E+02	.1087E+03	.2386E-03	.1929E-03	.2964E-03
			V=	.4266E+00	M/S	SOLVE-FOR	.2382E-02	.3198E-02	.7940E-02	.2186E+04	.1926E+04	.1137E+04
							.9277E-03	.9426E-03	.8953E-03			
570.0000	BEFORE	M=2121	P=	.1344E+03	KM	STATE	.3865E+02	.6905E+02	.1087E+03	.2386E-03	.1929E-03	.2964E-03
			V=	.4266E+00	M/S	SOLVE-FOR	.2382E-02	.3198E-02	.7940E-02	.2186E+04	.1926E+04	.1137E+04
							.9277E-03	.9426E-03	.8953E-03			
570.0000	AFTER	M=2121	P=	.1157E+03	KM	STATE	.3461E+02	.5917E+02	.9319E+02	.2258E-03	.1537E-03	.2425E-03
			V=	.3653E+00	M/S	SOLVE-FOR	.2382E-02	.3161E-02	.7916E-02	.2186E+04	.1926E+04	.1137E+04
							.9277E-03	.9425E-03	.8950E-03			
570.0000	BEFORE	M=4123	P=	.1157E+03	KM	STATE	.3461E+02	.5917E+02	.9319E+02	.2258E-03	.1537E-03	.2425E-03
	PRINT		V=	.3653E+00	M/S	SOLVE-FOR	.2382E-02	.3161E-02	.7916E-02	.2186E+04	.1926E+04	.1137E+04
							.9277E-03	.9425E-03	.8950E-03			
570.0000	AFTER	M=4123	P=	.1157E+03	KM	STATE	.3461E+02	.5917E+02	.9318E+02	.2257E-03	.1536E-03	.2424E-03
	PRINT		V=	.3651E+00	M/S	SOLVE-FOR	.2382E-02	.3160E-02	.7916E-02	.2180E+04	.1923E+04	.1129E+04
							.9127E-03	.9295E-03	.8743E-03			

3.2.3 SIMSEP

The SIMSEP sample case studies the last 50 days of the 1981 Slow Flyby Mission to comet Encke. The approach trajectory is simulated under the influence of control errors which directly affect the s/c motion, e.g. PG, EPHERR, TVERR, TCERR, etc., and knowledge errors which affect the ability to control the s/c motion, e.g. P, PS, and CXS. A single guidance correction has been included to demonstrate the effectiveness of the guidance algorithm in reducing target dispersions. Although the scope of this analysis in no way exercises the host of options available in SIMSEP, it does use the most fundamental computational cycles and displays the basic output format.

Referring to the sample printout (see pg. 119), the first page shows a listing of the $TRAJ namelist as has been presented in previous TOPSEP and GODSEP sample cases. The trajectory initialization data which follow define the reference trajectory integrating conditions underlying the SIMSEP analysis. Next, the first mode peculiar namelist, $SIMSEP, is listed and is followed by the SIMSEP initialization data on the two succeeding pages. Among the error sources are the initial s/c state (PG), the Encke ephemeris (EPHERR), s/c mass (SCERR(1)), exhaust velocity (SCERR(2)), and electric power to the thrusters (SCERR(3)). Thrust control biases (TCERR) in the reference control profile and thrust process noise (TVERR) are also input as error sources. For this run, NCYCLE is set equal to one, thus limiting the analysis to a single simulated trajectory.

Since only one guidance maneuver has been specified in the $SIMSEP input, i.e. NGUID = 1, only one $GUID namelist is read. The resultant

guidance initialization data are shown on the next three pages where the guidance event times, target times, active thrust control, and targets are identified. Because INREF = 1 in $SIMSEP, the s/c state and mass at the maneuver time, sensitivity matrix of targets with respect to controls, and nominal target conditions are input and printed. If INREF had been zero, trajectory information relevant to the guidance event would not be available at this point in program execution, but would have been computed and printed at a later time.

The trajectory simulation begins when the initial s/c errors and any errors that act as biases for the entire Monte Carlo cycle are sampled. For example, Encke ephemeris errors, thrust biases and the process noise correlation times are all sampled to form discrete "actual" values for the current cycle. These actual values and the corresponding reference values are printed as part of the actual trajectory initialization data.

The only maneuver in this simulation is a non-linear guidance correction scheduled to occur 567 days from launch, or just 24 days after the beginning of this Monte Carlo simulation. The active thrust controls are the cone and clock angles over the last two thrust phases (ten days each). The designated target time corresponds to the reference time of Encke encounter (593.5 from launch); this makes the duration of the guidance event 26.5 days. First, the orbit determination process is simulated to determine the estimated maneuver state; that is, the knowledge covariance samples are added to the actual state. Then the estimated trajectory conditions are propagated to the target stopping time, and the resultant target conditions (X, Y, Z relative to Encke) are computed. The miss (target variable

deviations on Page 130) is approximately 16,000 km and the quadratic error, Q, which must be driven to less than one for convergence, is 39.2. Various trajectory related matrices, Φ , Θ_u and η , are printed, along with the guidance matrix computed from these sensitivities. The first non-linear guidance correction (printed as "UPDATES" at bottom of Page 130) is estimated (.0593, .0072, -.0774, and .0105) and causes the estimated trajectory to come within 3000 km of the desired targets. The quadratic error resulting from these trajectory corrections is 1.4. Although a maximum of five iterations would be allowed before the mission would be declared divergent, the next set of thrust control updates brings the estimated trajectory within the 2500 km target tolerances, and convergence established. The commanded and executed thrust control corrections are printed, and the actual trajectory is propagated to the final time (TEND) since there are no more maneuvers. At TEND, a Monte Carlo mission summary is displayed showing the final trajectory conditions.

If more sample missions had been requested and run, additional output in the same format would result (if requested) as the computational cycle proceeded. This would, of course, include the sampling of initial errors, data for the guidance maneuver, and summary print. In the event that more than one mission simulation had been executed (without guidance divergence), additional output is displayed after all Monte Carlo cycles in the form of accumulated statistics (means, variances, and correlations). In particular, state error covariances, s/c mass variation, estimated control correction covariances, etc., would be printed and punched (if requested).

```
$TRAJ
  PRNML=T,
  ENGINE=21.65,.65,21.65, ENGINE(11)=.64,
  NB=3,10, NLP=3, NTP=10,
  ISTOP=2,
  TLNCH=2443956.65478,
  TSTART=543.,
  TEND=593.5,
  STATE=1.9484380956197E8,8.4084653563180E7,3.1421540207003E7,
  -22.4042728704607,8.1888959228917,-.0143403341129719,
  SCMASS=1551.3588053,
  ICOORD=0,
  THRUST(1,1)=9.,64.,5*0.,1.,2*0.,
  THRUST(1,2)=1.,140.,1.,69.1,224.6,2*0.,4.,2*0.,
  THRUST(1,3)=1.,230.,1.,75.,252.,2*0.,2.,2*0.,
  THRUST(1,4)=1.,310.,1.,85.334,269.,2*0.,2.,2*0.,
  THRUST(1,5)=1.,390.,1.,85.334,269.,2*0.,2.,2*0.,
  THRUST(1,6)=1.,470.,1.,85.334,269.,2*0.,3.,2*0.,
  THRUST(1,7)=1.,525.,1.,120.501,268.742,2*0.,3.,2*0.,
  THRUST(1,8)=1.,567.,1.355,129.6743,272.2092,2*0.,6.,2*0.,
  THRUST(1,9)=1.,577.,1.,150.64,80.,2*0.,7.,2*0.,
  THRUST(1,10)=1.,587.,1.,156.8614,78.0227,2*0.,7.,2*0.,
  THRUST(1,11)=9.,800.,5*0.,1.,2*0.,
  MODE=3,
  IPRINT=0,
$END
```

ORIGINAL PAGE IS
OF POOR QUALITY

TRAJECTORY INITIALIZATION

```
INITIAL EPOCH (REFERENCE DATE)
     JULIAN DATE ....    2443956.5547800004
     CALENDAR DATE ....  1979 MAR     24          3 HR 42 MIN 52.9920 SECS
TRAJECTORY START EPOCH        543.0000000000 DAYS AFTER THE INITIAL EPOCH
     JULIAN DATE ....    2444499.6547800004
     CALENDAR DATE ....  1980 SEP     17          3 HR 42 MIN 52.9920 SECS
TRAJECTORY END EPOCH          593.5000000000 DAYS AFTER THE INITIAL EPOCH
     JULIAN DATE ....    2444550.1547800004
     CALENDAR DATE ....  1980 NOV      6         15 HR 42 MIN 52.9920 SECS

INITIAL STATE VECTOR AT       543.0000000000 DAYS AFTER THE REFERENCE EPOCH
                               X                         Y                         Z                         MAGNITUDE
     POSITION         .194843803561972E+09     -.840346535631890E+08     -.314215402070003E+08     .214526577391146E+09
     VELOCITY        -.224842728704612E+02      .818389592289170E+01     -.143403341297190E-01     .238539234784730E+02
SEPS MASS                          1551.3588045300 KG
EXHAUST VELOCITY                     29.4180000000 KM/SEC
ELECTRIC POWER AT 1 A. U.            21.6500000000 KW
THRUSTER EFFICIENCY                    .6400000000
RADIATION PRESSURE COEFFICIENT       -1.0000000000

LIST OF GRAVITATING BODIES
     SUN
     EARTH
     ENCKE
TARGET PLANET IS ENCKE

INTEGRATION STEP FACTOR       .0500

REFERENCE THRUST CONTROLS
```

THRUST PHASE NUMBER	THRUST PHASE END TIME (DAY)	THRUST PHASE THROTTLING	THRUST PHASE CONE ANGLE (DEG)	THRUST PHASE CLOCK ANGLE (DEG)	THRUST PHASE CONE RATE (DEG/SEC)	THRUST PHASE CLOCK RATE (DEG/SEC)	NUMBER OF THRUSTERS
1	64.000000	0.000000	0.000000	0.000000	0.000000	0.000000	1.000000
2	140.000000	1.000000	68.150000	224.600000	0.000000	0.000000	4.000000
3	270.000000	1.000000	75.000000	252.000000	0.000000	0.000000	2.000000
4	310.000000	1.000000	85.334000	269.000000	0.000000	0.000000	2.000000
5	395.000000	1.000000	85.334000	269.000000	0.000000	0.000000	2.000000
6	470.000000	1.000000	85.334000	269.000000	0.000000	0.000000	3.000000
7	525.000000	1.000000	120.501000	268.742000	0.000000	0.000000	3.000000
8	567.000000	1.355000	129.674300	272.209200	0.000000	0.000000	6.000000
9	577.000000	1.000000	150.640000	30.000000	0.000000	0.000000	7.000000
10	587.000000	1.000000	156.881400	78.022700	0.000000	0.000000	7.000000
11	880.000000	0.000000	0.000000	0.000000	0.000000	0.000000	1.000000

```
BODY PARAMETERS AND ORBITAL ELEMENTS HAVE BEEN READ-IN FOR ENCKE  AT JULIAN DATE....2444580.000000000000
     PLANET RADIUS                   .500000000000E+03 KM
     PLANET SPHERE                   .100000000000E+04 KM
     PLANET GRAVITATIONAL CONSTANT   .100000000000E-08 KM**3/SEC**2
     SEMI-MAJOR AXIS      .331808125700E+09 KM     0.                   KM/JC
     ECCENTRICITY         .847000000000E+00        0.                   1.0/JC
     INCLINATION          .119500000000E+02 DEG    0.                   DEG/JC
     ASCENDING NODE       .334200000000E+03 DEG    0.                   DEG/JC
     OMEGA-T              .160200000000E+03 DEG    0.                   DEG/JC
     MEAN ANOMALY      0.                   DEG    0.                   DEG/JC
```

ORIGINAL PAGE IS OF POOR QUALITY

```
$SIMSEP
  IOUT=1, IPUNCH=1, IRAN=1,
  NGUID=1, NCYCLE=1, INREF=1,
  EPHERR(1,1,1)=1000., EPHERR(2,2,1)=1000., EPHERR(3,3,1)=1000.,
  EPHERR(4,4,1)=7.E-5, EPHERR(5,5,1)=7.E-5, EPHERR(6,6,1)=7.E-5,
  NEP2(1)=10, TEPH(1)=593.5,
  PG(1,1)=146.3,.3449,.4002,.8757,.3109,.3537,
  PG(2,2)=473.0,.3166,.3720,.8651,.4245,
  PG(3,3)=148.0,.3426,.3183,.8401,
  PG(4,4)=.6060E-3,.4307,.3905,
  PG(5,5)=.2355E-2,.5329,
  PG(6,6)=.5571E-3,
  SCERR(1)=.005, SCERR(2)=.0005, SCERR(3)=.005,
  TCERR(2,7)=.002,2*.02,
  TCERR(2,8)=.002,2*.02,
  TCERR(2,9)=.002,2*.02,
  TCERR(2,10)=.002,2*.02,
  TVERR(1,1)=.01,.573,.573,
  TVERR(1,2)=2.,.125,.125,3*1.,
  TVERR(1,3)=.2,.0125,.0125,
 XEND=          .637952007701E+08,     .955745797681E+08,     .240878516603E+08,
          -.398464859389E+02,  -.671498459981E+01,  -.437028247409E+01,
 MEND=          .144302538776E+04
  PRNML=T,
$END
```

SIMSEP INPUT DATA

INITIAL CONTROL COVARIANCE AT TRAJECTORY TIME 543.00000 DAYS(J.D.= 2444499.65478)

STANDARD DEVIATIONS AND CORRELATIONS

	X	Y	Z	VX	VY	VZ
X	.146300000000E+03					
Y	.3449000000	.473000000000E+03				
Z	.4302000000	.3186000000	.148000000000E+03			
VX	.3757000000	.3720000000	.3426000000	.696000000000E-03		
VY	.3110000000	.9651000000	.3183000000	.4307000000	.235500000000E-02	
VZ	.7537000000	.4245000000	.8401000000	.3905000000	.5329000000	.557100000000E-03

VARIANCES AND COVARIANCES

	X	Y	Z	VX	VY	VZ
X	.214036900000E+05	.238670455100E+05	.866529048000E+04	.776376354600E-01	.107116397850E+03	.238273693010E-01
Y	.238670455100E+05	.223729000000E+06	.223032744000E+05	.106629336000E+00	.963647866500E+00	.111659273350E+00
Z	.866529048000E+04	.223032744000E+05	.219040000000E+05	.307271088000E-01	.110940282000E+00	.692669170800E-01
VX	.776376354600E-01	.106629336000E+00	.307271088000E-01	.367236000000E-06	.614664891000E-06	.131833815300E-06
VY	.107116397850E+00	.963647866500E+00	.110940282000E+00	.614664891000E-06	.554602500000E-05	.699149079450E-06
VZ	.238273693010E-01	.111659273350E+00	.692669170800E-01	.131833815300E-06	.699149079450E-06	.310360410000E-06

EIGENVALUES OF THE INITIAL COVARIANCE

.129537358773E+05 .229096276306E+06 .249721079218E+05 .715062881228E-07 .142228234227E-05 .563530004107E-07

MATRIX OF EIGENVECTORS (IN COLUMNS)

EGVEC1	EGVEC2	EGVEC3	EGVEC4	EGVEC5	EGVEC6
.773577043002E+00	.118032444119E+00	.672225478928E+00	-.304106106567E-05	-.340989871513E-06	.180549978291E-05
-.135498744472E-01	.986763651539E+00	-.161791033484E+00	.465365974693E-06	-.421292199125E-05	.132360706431E-05
-.634242761663E+00	.111157412961E+00	.722451782220E+00	-.113871240408E-05	-.112793662096E-05	-.261154736792E-05
.257136572229E-05	.514184664162E-06	.228814010664E-05	.866244886326E+00	.106793504006E+00	-.464534655889E+00
-.584979211727E-06	.425966133771E-05	-.150334772019E-06	-.155967633633E+00	.985830841742E+00	-.622157348367E-01
-.211131155089E-05	.530263439750E-06	.205521346292E-05	.470982923913E+00	.129585835090E+00	.872572401992E+00

EPHEMERIS PLANET 1 IS ENCKE

EPHEMERIS PLANET REFERENCE STATE VECTOR AT EPOCH 2444550.1547800004

X	.637955034366E+08	Y	.955744157296E+08	Z	.240880356655E+08
VX	-.416956361292E+02	VY	-.866835907743E+01	VZ	-.551090535280E+01

STANDARD DEVIATIONS AND CORRELATIONS

	X	Y	Z	VX	VY	VZ
X	.100000000000E+04					
Y	0.0000000000	.100000000000E+04				
Z	0.0000000000	0.0000000000	.100000000000E+04			
VX	0.0000000000	0.0000000000	0.0000000000	.700000000000E-04		
VY	0.0000000000	0.0000000000	0.5000000000	0.0000000000	.700000000000E-04	
VZ	0.0000000000	0.0000000000	0.0000000000	0.0000000000	0.0000000000	.700000000000E-04

VARIANCES AND COVARIANCES

	X	Y	Z	VX	VY	VZ
X	.100000000000E+07	0.	0.	0.	0.	0.
Y	0.	.100000000000E+07	0.	0.	0.	0.
Z	0.	0.	.100000000000E+07	0.	0.	0.
VX	0.	0.	0.	.490000000000E-08	0.	0.
VY	0.	0.	0.	0.	.490000000000E-08	0.
VZ	0.	0.	0.	0.	0.	.490000000000E-08

EIGENVALUES OF THE CARTESIAN EPHEMERIS ERROR COVARIANCE

.100000000000E+07	.100000000000E+07	.100000000000E+07	.490000000000E-08	.490000000000E-08	.490000000000E-08

MATRIX OF EIGENVECTORS (IN COLUMNS)

EGVEC1	EGVEC2	EGVEC3	EGVEC4	EGVEC5	EGVEC6
.100000000000E+01	0.	0.	0.	0.	0.
0.	.100000000000E+01	0.	0.	0.	0.
0.	0.	.100000000000E+01	0.	0.	0.
0.	0.	0.	.100000000000E+01	0.	0.
0.	0.	0.	0.	.100000000000E+01	0.
0.	0.	0.	0.	0.	.100000000000E+01

UNCERTAINTIES IN THE FOLLOWING SEPS PARAMETERS (ONE-SIGMA)

	NOMINAL VALUE	STANDARD DEVIATION
S/C MASS	1551.3588045300	.0050000000 KG
EXHAUST VELOCITY	29.4180000000	.0005000000 KM/SEC
ELECTRIC POWER AT 1 A.U.	21.6500000000	.0050000000 KW

THRUST CONTROL ERRORS (ONE-SIGMA)

THRUST PHASE NUMBER	THRUST PHASE END TIME (DAY)	THRUST PHASE THROTTLING	THRUST PHASE CONE ANGLE (DEG)	THRUST PHASE CLOCK ANGLE (DEG)	THRUST PHASE CONE RATE (DEG/SEC)	THRUST PHASE CLOCK RATE (DEG/SEC)
8	0.000000	.002000	.020000	.020000	0.000000	0.000000
9	0.000000	.002000	.020000	.020000	0.000000	0.000000
10	0.000000	.002000	.020000	.020000	0.000000	0.000000
11	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000

TIME-VARYING THRUST ERRORS

	ONE-SIGMA LEVEL	CORRELATION TIME	STANDARD DEVIATION IN CORRELATION TIME
THROTTLING	.100000000000E-01	.200000000000E+01	.200000000000E+00
CONE ANGLE	.573000000000E+00	.125000000000E+00	.125000000000E-01
CLOCK ANGLE	.573000000000E+00	.125000000000E+00	.125000000000E-01
THROTTLING	0.	.100000000000E+01	0.
CONE ANGLE	0.	.100000000000E+01	0.
CLOCK ANGLE	0.	.100000000000E+01	0.

```
$GUID
  TGUID=567.01, TTARG=593.5,
  IGUID=+2,
  NTP=10, NEP=10,
  ITARGT=1,2,3,
  NMAX=5,
  TARTOL=3*2500.,
  H(4,9)=1., H(5,9)=1.,
  H(4,10)=1., H(5,10)=1.,
  KDIMEN=12,
  P(1,1)=56.73,-.70,.13,.59,-.12,.02,
  P(2,2)=23.14,-.79,-.42,.37,-.50,
  P(3,3)=37.23,.13,-.32,.68,
  P(4,4)=2.78E-4,.13,.03,
  P(5,5)=2.22E-4,-.41,
  P(6,6)=1.97E-4,
  PS(1,1)=441.,.61,.35,.90,-.44,.02,
  PS(2,2)=764.,.52,.87,-.86,-.15,
  PS(3,3)=363.,.57,-.43,-.63,
  PS(4,4)=6.91E-5,-.67,-.17,
  PS(5,5)=1.05E-4,.15,
  PS(6,6)=5.16E-5,
 XGREF=     .141936714399E+09,     .968736907210E+08,     .301565939457E+08,
          -.288998061950E+02,     .362808335578E+01,    -.133027741283E+01,
 MGREF=     .149342647159E+04,
 XTREF=    -.302671830177E+03,    -.235964598179E+03,    -.184006249666E+03,
           .204895016934E+01,     .195337447944E+01,     .114062287871E+01,
 MTREF=     .144342538775E+04,
 TARGET=   -.302671830177E+03,    -.235964598179E+03,    -.184006249666E+03,
 S=         .623954438172E+05,    -.852658367394E+06,     .415844218605E+05,
          -.965253685367E+05,     .142732346640E+05,     .393442788574E+06,
           .161784711477E+06,    -.502596048424E+06,     .562322738143E+05,
          -.578103928192E+05,     .399409458368E+04,     .201159293357E+06,
  PRNML=T,
$END
```

```
****************************************************** GUIDANCE EVENT NUMBER 1 ******************************************************
*********************************************************** INPUT DATA ***********************************************************

GUIDANCE EVENT TIME       2444523.66478 AT  567.01000 DAYS FROM LAUNCH
DESIGNATED TARGET TIME    2444550.15478 AT  593.50000 DAYS FROM LAUNCH
DURATION OF THE GUIDANCE TRAJECTORY IS   26.49000 DAYS

REFERENCE TRAJECTORY STATE VECTOR AT THE GUIDANCE EVENT(J.D.=  2444523.66478)
     X           .141936714399E+09 KM
     Y           .960736907210E+09 KM
     Z           .301565939457E+03 KM
     VX         -.286938051950E+02 KM/SEC
     VY          .362808735578E+01 KM/SEC
     VZ         -.133027741283E+01 KM/SEC

SEPS MASS
     1493.42647 KG

CURRENT THRUST PHASE NUMBER
          9

SENSITIVITY MATRIX OF TARGET VARIABLES W.R.T. CONTROL VARIABLES( 3 X  4 )
     .523954478177E+05  -.385253685367E+05   .161734711477E+06  -.578103928192E+05
    -.252658767794E+06   .142732346640E+05  -.502596046424E+08   .399409458368E+04
     .415044213605E+05   .393442788574E+06   .562322738136E+05   .201159293357E+06

REFERENCE TRAJECTORY STATE VECTOR AT THE TARGET TIME(J.D.=  2444550.15478)
     X          -.302671830177E+03 KM
     Y          -.235964538173E+03 KM
     Z          -.184036249666E+03 KM
     VX          .204895013934E+01 KM/SEC
     VY          .195337447944E+01 KM/SEC
     VZ          .114062287871E+01 KM/SEC

SEPS MASS
     1443.42539 KG

DESIGNATED TARGET VARIABLES
                    TARGET VALUES          TOLERANCE
          X      -.302671630177E+03   .250000000000E+04 KM
          Y      -.235964598179E+03   .250000000000E+04 KM
          Z      -.184006249666E+03   .250000000000E+04 KM

EFFECTIVE TARGET PLANET FOR THIS GUIDANCE EVENT IS ENCKE

EFFECTIVE EPHEMERIS PLANET FOR THIS GUIDANCE EVENT IS ENCKE

THE GUIDANCE LAW FOR THIS EVENT IS LOW THRUST-NONLINEAR WITH    5 ITERATION(S)

SENSITIVITY MATRICES OF TARGET CHANGE PER CONTROL CHANGE ARE COMPUTED BY INTEGRATING VARIATIONAL EQUATIONS FOR
BOTH IMPULSIVE AND LOW THRUST GUIDANCE.

ACTIVE THRUST CONTROLS FOR THIS GUIDANCE EVENT
                    THRUST PHASE NUMBER     CONTROL VARIABLES
                           9                  CONE ANGLE
                           9                  CLOCK ANGLE
                          10                  CONE ANGLE
                          10                  CLOCK ANGLE

WEIGHTS SPECIFIED FOR EACH CONTROL VARIABLE.
     .100000000000E+01   .100000000000E+01   .100000000000E+01   .100000000000E+01
```

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OF POOR QUALITY

P MATRIX

.567300000000E+02	-.700000000000E+00	.130000000000E+00	.590000000000E+00	-.120000000000E+00	.200000000000E-01
-.700000000000E+00	.231400000000E+02	-.790000000000E+00	-.420000000000E+00	.370000000000E+00	-.500000000000E+00
.130000000000E+00	-.790000000000E+00	.372300000000E+02	.130000000000E+00	-.320000000000E+00	.680000000000E+00
.590000000000E+00	-.420000000000E+00	.130000000000E+00	.278000000000E-03	.130000000000E+00	.300000000000E-01
-.120000000000E+00	.770000000000E+00	-.320000000000E+00	.130000000000E+00	.222000000000E-03	-.410000000000E+00
.200000000000E-01	-.500000000000E+00	.680000000000E+00	.300000000000E-01	-.410000000000E+00	.197000000000E-03

PS MATRIX

.441000000000E+03	.610000000000E+00	.350000000000E+00	.900000000000E+00	-.440000000000E+00	.200000000000E-01
.610000000000E+00	.764000000000E+03	.520000000000E+00	.370000000000E+00	-.860000000000E+00	-.150000000000E+00
.350000000000E+00	.520000000000E+00	.363000000000E+03	.570000000000E+00	-.430000000000E+00	-.630000000000E+00
.900000000000E+00	.570000000000E+00	.570000000000E+00	.691000000000E-04	-.670000000000E+00	-.173000000000E+00
-.440000000000E+00	-.860000000000E+00	-.430000000000E+00	-.670000000000E+00	.105000000000E-03	.150000000000E+00
.200000000000E-01	-.150000000000E+00	-.630000000000E+00	-.170000000000E+00	.150000000000E+00	.516000000000E-04

CXS MATRIX

0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.

AUG-P MATRIX

.321829290000E+04	-.918912540000E+03	.274567527000E+03	.930485460000E-02	-.151128720000E-02	.223516200000E-03	0.	0.	0.	0.	0.	0.
-.918912540000E+03	.535459600000E+03	-.680586738000E+03	-.270182640000E-02	.190071960000E-02	-.227929000000E-02	0.	0.	0.	0.	0.	0.
.274567527000E+03	-.680586738000E+03	.138607290000E+04	.134549220000E-02	-.264481920000E-02	.498733080000E-02	0.	0.	0.	0.	0.	0.
.930485460000E-02	-.270182640000E-02	.134549220000E-02	.772840000000E-07	.802308000000E-08	.164298000000E-08	0.	0.	0.	0.	0.	0.
-.151128720000E-02	.190071960000E-02	-.264481920000E-02	.802308000000E-08	.492840000000E-07	-.179309400000E-07	0.	0.	0.	0.	0.	0.
.223516250000E-03	-.227929000000E-02	.498733080000E-02	.164298000000E-08	-.179309400000E-07	.388390000000E-07	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	[illegible]	.205523640000E+06	.560291500000E+05	.274257900000E-01	-.203742000000E-01	.455112000000E-03
0.	0.	0.	0.	0.	0.	.205523640000E+06	-.583696000000E+06	.144212640000E+06	.459293880000E-01	-.639892000000E-01	-.591336000000E-02
0.	0.	0.	0.	0.	0.	.560290500000E+05	.144212640000E+06	.131769000000E+06	.142974810000E-01	-.163894500000E-01	-.118004040000E-01
0.	0.	0.	0.	0.	0.	.274257900000E-01	.459293880000E-01	.142974810000E-01	.477461000000E-08	-.486118500000E-08	-.606145200000E-09
0.	0.	0.	0.	0.	0.	-.203742000000E-01	-.689892000000E-01	-.163894500000E-01	-.486118500000E-08	.110250000000E-07	.812700000000E-09
0.	0.	0.	0.	0.	0.	.455112000000E-03	-.591336000000E-02	-.118004040000E-01	-.606145200000E-09	.812700000000E-09	.266256000000E-08

EIGENVECTORS

```
      .921306557971E+00    .221172594637E+00   -.318073861702E+00   -.121591624321E-04   -.828273713912E-05   -.609579734801E-05
        0.                   0.                   0.                   0.                   0.                   0.
     -.327377369173E+00    .891445866898E+00   -.317413007504E+00   -.379473420730E-04   -.361198052095E-04   -.267329714211E-04
        0.                   0.                   0.                   0.                   0.                   0.
      .213342571380E+00    .395487179759E+00    .893352114877E+00   -.165329039466E-04   -.122817837841E-04   -.136236697483E-04
        0.                   0.                   0.                   0.                   0.                   0.
      .279214683556E-05    .328718339149E-04   -.588209815258E-06    .976638497043E+00   -.198777924616E+00   -.524788310327E-01
        0.                   0.                   0.                   0.                   0.                   0.
     -.713566746423E-06    .567548387777E-04   -.162428413066E-05    .190553556784E+00    .781197704041E+00    .594490946923E+00
        0.                   0.                   0.                   0.                   0.                   0.
      .556896271146E-06   -.181067932428E-05    .333816202118E-05   -.771753344052E-01   -.591791755909E+00    .802387989336E+00
        0.                   0.                   0.                   0.                   0.                   0.
    0.                   0.                   0.                   0.                   0.                   0.
          .907772799442E+00    .379819598842E+00    .178004541876E+00   -.907198567522E-07   -.395011225996E-07   -.159330048253E-07
    0.                   0.                   0.                   0.                   0.                   0.
         -.304591713094E+00    .888646157872E+00   -.342829223727E+00   -.503076538999E-07    .126897993347E-06   -.110983464780E-07
    0.                   0.                   0.                   0.                   0.                   0.
         -.288396312229E+00    .256992335805E+00    .922373721800E+00   -.163270065817E-07   -.560187568279E-09    .110847912276E-06
    0.                   0.                   0.                   0.                   0.                   0.
          .529719723271E-07    .769807717439E-07    .261142828286E-07    .993958133316E+00    .692137701738E-01   -.851861680903E-01
    0.                   0.                   0.                   0.                   0.                   0.
          .672532425036E-07   -.102710072194E-06    .551526983423E-07   -.737783627639E-01    .995936109372E+00   -.516523782706E-01
    0.                   0.                   0.                   0.                   0.                   0.
          .521498632525E-07   -.113770649963E-07   -.986297304556E-07    .812648903492E-01    .576256944781E-01    .995302527451 9E+00
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EIGENVALUES

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      .363415946898E+04    .553524286285E+01    .153013068824E+04    .451424273583E-07    .305482072857E-07    .149962009485E-07
          .197719897404E+06    .713245255784E+06    .889603460119E+05    .5[illegible]922253393E-10    .276118206694E-08    .141634436115E-08
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(CORE REQUIREMENTS FOR THIS JOB,  077400 OCTAL)
(LENGTH OF BLANK COMMON FOR THIS JOB,  001713 OCTAL)
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******************************************************************************************************************************
                                                       END OF SIMSEP INPUT
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MONTE CARLO CYCLE NUMBER 1

OUTPUT DATA FOR THE ACTUAL TRAJECTORY AT TRAJECTORY INITIALIZATION

S/C STATE VECTOR AT TRAJECTORY TIME = 543.00000 DAYS(J.D.= 2444499.65478)

	ACTUAL	REFERENCE	DEVIATION	
X	.194643919023E+09	.194843809562E+09	.109460810661E+03	KM
Y	.840849846964E+08	.840846535632E+08	.331133160618E+03	KM
Z	.314214644455E+08	.314215402070E+08	-.757614690065E+02	KM
VX	-.224036481876E+02	-.224042728705E+02	.624682910029E-03	KM/SEC
VY	.818692844689E+01	.818889592289E+01	.325239977315E-04	KM/SEC
VZ	-.145663740329E-01	-.143403341297E-01	-.226639953224E-03	KM/SEC

SAMPLED S/C-SEP PARAMETERS

	ACTUAL	REFERENCE	DEVIATION	
S/C MASS	1551.35804	1551.35880	-.00077	KG
EXHAUST VELOCITY	29.41857	29.41800	.00057	KM/SEC
ELECTRIC POWER	21.65059	21.65000	.00059	KW

DEVIATION OF THE ACTUAL THRUST CONTROLS FROM THE REFERENCE VALUES AFTER SAMPLING THRUST BIASES

THRUST PHASE NUMBER	THRUST PHASE END TIME (DAY)	THRUST PHASE THROTTLING	THRUST PHASE CONE ANGLE (DEG)	THRUST PHASE CLOCK ANGLE (DEG)	THRUST PHASE CONE RATE (DEG/SEC)	THRUST PHASE CLOCK RATE (DEG/SEC)
8	0.000000	-.000509	.000946	.002885	0.000000	0.000000
9	0.000000	-.000282	-.002368	.006564	0.000000	0.000000
10	0.000000	-.001019	.022327	-.004997	0.000000	0.000000
11	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000

RECIPROCALS OF DIAGONAL ELEMENTS OF THE THRUST PROCESS TIME CORRELATION MATRIX

FIRST PROCESS =	2.0390608269	.1202974245	.1202714190	(DAYS)
SECOND PROCESS =	1.0000000000	1.0000000000	1.0000000000	(DAYS)

INITIAL VALUES FOR THE THRUST PROCESS NOISE

	FIRST PROCESS	SECOND PROCESS
THRUST MAGNITUDE	-.0019548827	0.0000000000
CONE ANGLE (DEG)	-.0473161942	0.0000000000
CLOCK ANGLE (DEG)	-.2465761609	0.0000000000

FIRST EPHEMERIS PLANET IS ENCKE

CARTESIAN STATE VECTOR FOR THE EPHEMERIS PLANET AT 593.50000 DAYS(J.D.= 2444550.15478)

	ACTUAL	REFERENCE	DEVIATION	
X	.637951874020E+08	.637955087436E+08	.683965225935E+03	KM
Y	.955750513687E+08	.955748157296E+08	.265830144230E+03	KM
Z	.240887345784E+08	.240860356655E+08	.298912932754E+03	KM
VX	-.418953565312E+02	-.418954361292E+02	.795979791729E-04	KM/SEC
VY	-.866833742451E+01	-.866835907743E+01	.216529214754E-04	KM/SEC
VZ	-.551091501194E+01	-.551090535280E+01	-.965913633875E-03	KM/SEC

KEPLERIAN ELEMENTS FOR THE EPHEMERIS PLANET EVALUATED AT 593.50000 DAYS(J.D.= 2444550.15478)

	ACTUAL	REFERENCE	DEVIATION	
SMJ AXIS	.331812743589E+09	.331808126700E+09	.461688936043E+04	KM
ECC	.8470023	.8470000	.0000023	
INC	11.9500946	11.9500000	.0000946	DEG
NODE	334.2001899	334.2000000	.0001899	DEG
APSIS	185.9998745	186.0000000	-.0001255	DEG
MEAN ANO	351.0950763	351.0949463	.0001301	DEG

ORIGINAL PAGE IS OF POOR QUALITY

MONTE CARLO CYCLE NUMBER 1
GUIDANCE EVENT NUMBER 1
OUTPUT DATA FOR GUIDANCE EVENT

GUIDANCE EVENT TIME 2444523.66478 AT 567.01000 DAYS FROM LAUNCH
DESIGNATED TARGET TIME 2444550.15478 AT 593.50000 DAYS FROM LAUNCH
DURATION OF THE GUIDANCE TRAJECTORY IS 26.49000 DAYS

S/C STATE VECTOR AT TRAJECTORY TIME = 567.01000 DAYS(J.D.= 2444523.66478)

		ACTUAL	REFERENCE	DEVIATION	
	X	.141940908329E+09	.141936714399E+09	.419392983818E+04	KM
	Y	.368730546137E+08	.368736907210E+08	.436389266968E+04	KM
	Z	.301554434755E+08	.301565979457E+08	-.114959823155E+04	KM
	VX	-.288978263804E+02	-.288998061950E+02	.197981458314E-02	KM/SEC
	VY	.363058701493E+01	.362808335578E+01	.250365915062E-02	KM/SEC
	VZ	-.133097374843E+01	-.133027741283E+01	-.696335596878E-03	KM/SEC
S/C MASS		1493.55679	1493.42647	.13032	KG

ESTIMATED S/C STATE VECTOR FROM SIMULATED ORBIT DETERMINATION

		ESTIMATE	ACTUAL	DEVIATION	
	X	.141940933741E+09	.141940908329E+09	-.254120883942E+02	KM
	Y	.368730815345E+08	.368730546137E+08	.268907352173E+02	KM
	Z	.301553792344E+08	.301554434755E+08	-.651130414009E+02	KM
	VX	-.288974348208E+02	-.288978263804E+02	.391559655395E-03	KM/SEC
	VY	.363102235267E+01	.363058701493E+01	.435837738479E-03	KM/SEC
	VZ	-.133124025246E+01	-.133097374843E+01	-.266504029121E-03	KM/SEC
S/C MASS		1493.42647	1493.55679	-.13032	KG

ESTIMATED EPHEMERIS PLANET CARTESIAN STATE PREDICTED TO TRAJECTORY TIME 593.50000 DAYS(J.D.= 2444550.15478)

	ESTIMATE	ACTUAL	DEVIATION	
X	.637963240308E+08	.637961874020E+08	.136628831387E+03	KM
Y	.955754420972E+08	.955750815067E+08	.360528486729E+03	KM
Z	.240884042362E+08	.240883345784E+08	.696578236818E+02	KM
VX	-.418953263903E+02	-.418953565312E+02	.301404627407E-04	KM/SEC
VY	-.866844591648E+01	-.866833742451E+01	-.108491975539E-03	KM/SEC
VZ	-.551095746483E+01	-.551091501194E+01	-.424528858787E-04	KM/SEC

KEPLERIAN ELEMENTS FOR THE EPHEMERIS PLANET EVALUATED AT 593.50000 DAYS(J.D.= 2444550.15478)

	ACTUAL	REFERENCE	DEVIATION	
SMJ AXIS	.331818629440E+09	.331812743589E+09	.595585055351E+04	KM
ECC	.0470049	.0470023	.0000026	
INC	11.9500822	11.9500946	-.0000125	DEG
NODE	334.1999469	334.2001899	-.0002430	DEG
APSIS	186.0001644	185.9998745	.0002899	DEG
MEAN ANO	351.0952918	351.0950763	.0002155	DEG

ESTIMATED TRAJECTORY CONDITIONS FOR NONLINEAR TARGETING

ITERATION NUMBER 1

TRAJECTORY STATE AT 593.50000 DAYS(J.D.= 2444550.15478)

	ESTIMATE	REFERENCE	DEVIATION	
X	.963260029912E+04	-.302671830177E+03	.101352721293E+05	KM
Y	.113070314326E+05	-.235964598179E+03	.115429960308E+05	KM
Z	-.324792625213E+04	-.184006249666E+03	-.306392000246E+04	KM
VX	.205269349651E+01	.204895018934E+01	.374330717028E-02	KM/SEC
VY	.195796943911E+01	.195337447944E+01	.459495966794E-02	KM/SEC
VZ	.114064730579E+01	.114062287871E+01	.250270753455E-04	KM/SEC
S/C MASS	1443.42747	1443.42539	.00209	KG

TARGET VARIABLES

	ESTIMATE	REFERENCE	DEVIATION	
X	.983260029912E+04	-.302671830177E+03	.101352721293E+05	KM
Y	.113470314326E+05	-.235964598179E+03	.115429960308E+05	KM
Z	-.324792625213E+04	-.184006249666E+03	-.306392000246E+04	KM

QUADRATIC ERROR FUNCTION TO MEASURE RATE OF CONVERGENCE
Q = .392563366854E+02 FOR ITERATION NUMBER 1

PHI MATRIX OVER TRAJECTORY ARC 567.01000 TO 593.50000 DAYS

	X	Y	Z	VX	VY	VZ
X	.195877276255E+01	.145242125357E+00	.392303521171E-01	.233257862538E+07	.130714830540E+06	.349349398643E+05
Y	.143391356170E+00	.132438203569E+01	.413119213601E-01	.130136073461E+06	.232452320155E+07	.381837370290E+05
Z	.422872432131E-01	.399266979708E-01	.904311397564E+00	.365412209169E+05	.373866163028E+05	.220439365243E+07
VX	.530715697676E-07	.154062839187E-06	.413387225273E-07	.134205427501E+01	.205450001651E+00	.543471442332E-01
VY	.159141798777E-06	.559553411611E-07	.473145654482E-07	.208515688934E+00	.109288119182E+01	.651112345273E-01
VZ	.414181137290E-07	.460075315857E-07	-.952716545161E-07	.559815718946E-01	.643104134561E-01	.871839216905E+00

THETA MATRIX OVER TRAJECTORY ARC 567.01000 TO 593.51000 DAYS
(ALL ELEMENTS ARE IN INTERNAL UNITS)

	CONE ANGLE	CLOCK ANGLE	CONE ANGLE	CLOCK ANGLE
X	.624061624947E+05	-.985147117595E+05	.161786665342E+06	-.578048962196E+05
Y	-.352596138719E+06	.142751159380E+05	-.502580026934E+06	.399770833626E+04
Z	.415933126464E+05	.393420361753E+06	.562385050165E+05	.201155750524E+06
VX	-.497806182101E-02	-.476838119385E-01	.153954139983E+00	-.566730176795E-01
VY	-.481559734202E+00	.948945138971E-02	-.509501771350E+00	.330389125042E-02
VZ	.588392178256E-02	.198547944772E+00	.516378350817E-01	.197853332443E+00

ETA MATRIX AT THE TARGET POINT
(ALL ELEMENTS ARE IN INTERNAL UNITS)

	X	Y	Z	VX	VY	VZ
X	.100000000000E+01	0.	0.	0.	0.	0.
Y	0.	.100000000000E+01	0.	0.	0.	0.
Z	0.	0.	.100000000000E+01	0.	0.	0.

TARGET/CONTROL SENSITIVITY MATRIX(3 X 4)
(ALL ELEMENTS ARE IN INTERNAL UNITS)

	CONE ANGLE	CLOCK ANGLE	CONE ANGLE	CLOCK ANGLE
X	.624061624947E+05	-.985147117595E+05	.161786665342E+06	-.578048962196E+05
Y	-.352593178719E+06	.142751159380E+05	-.502560026934E+06	.399770833626E+04
Z	.415933126464E+05	.393420361753E+06	.562395050165E+05	.201155750524E+06

GUIDANCE MATRIX(4 X 3) FOR NONLINEAR GUIDANCE CORRECTION
(ALL ELEMENTS ARE IN INTERNAL UNITS)

	X	Y	Z
CONE ANGLE	-.441978442958E-05	-.154821913211E-05	-.103997998784E-05
CLOCK ANGLE	-.232813726698E-05	.351748358034E-07	.194325412083E-05
CONE ANGLE	.748554203016E-05	.639092605022E-06	.191113526199E-05
CLOCK ANGLE	-.723551722215E-06	-.466463868694E-07	.851856554360E-06

ESTIMATED CONTROL CORRECTION FOR ITERATION 1 IN INTERNAL UNITS

	OLD CONTROLS	UPDATES	NEW CONTROLS
CONE ANGLE	.262916398520E+01	.593273163172E-01	.268849130152E+01
CLOCK ANGLE	.139626340160E+01	.721895273143E-02	.140348235433E+01
CONE ANGLE	.273809606514E+01	-.773694833975E-01	.266070748179E+01
CLOCK ANGLE	.136175300670E+01	.104818591267E-01	.137223486542E+01

ORIGINAL PAGE IS OF POOR QUALITY

ESTIMATED TRAJECTORY CONDITIONS FOR NONLINEAR TARGETING

ITERATION NUMBER 2

TRAJECTORY STATE AT 593.50000 DAYS(J.D.= 2444550.15478)

	ESTIMATE	REFERENCE	DEVIATION	
X	.248241891074E+04	-.302671830177E+03	.278509074092E+04	KM
Y	.505576013603E+03	-.235964598179E+03	.741500611782E+03	KM
Z	.558642783165E+03	-.184006249666E+03	.742649032831E+03	KM
VX	.204146794342E+01	.204895018934E+01	-.746624592415E-02	KM/SEC
VY	.195974442572E+01	.195337447944E+01	.163699462779E-01	KM/SEC
VZ	.114134858083E+01	.114062287871E+01	.725702117826E-03	KM/SEC
S/C MASS	1443.42663	1443.42539	.00124	KG

TARGET VARIABLES

	ESTIMATE	REFERENCE	DEVIATION	
X	.248241891074E+04	-.302671873177E+03	.278509074092E+04	KM
Y	.505536013603E+03	-.235964598179E+03	.741500611782E+03	KM
Z	.558642783165E+03	-.184006249666E+03	.742649032831E+03	KM

QUADRATIC ERROR FUNCTION TO MEASURE RATE OF CONVERGENCE

Q = .392563366854E+02 FOR ITERATION NUMBER 1

Q = .141723293854E+01 FOR ITERATION NUMBER 2

PHI MATRIX OVER TRAJECTORY ARC 567.01000 TO 593.50000 DAYS

	X	Y	Z	VX	VY	VZ
X	.135876355739E+01	.145321485478E+00	.392367574284E-01	.233275943915E+07	.130816415531E+06	.349357796567E+05
Y	.144736346985E+00	.102458731742E+01	.414336854076E-01	.130307374767E+06	.232451385644E+07	.382132822501E+05
Z	.422659737367E-01	.397142357982E-01	.904145501431E+00	.365317333500E+05	.373263344569E+05	.220442770545E+07
VX	.532346037230E-07	.154172903513E-06	.414023046457E-07	.104230549772E+01	.205531899993E+00	.543639725832E-01
VY	.159370739546E-06	.560276019690E-07	.473775048992E-07	.208691808792E+00	.109283202066E+01	.651339275616E-01
VZ	.441415274955E-07	.459215602582E-07	-.952991180397E-07	.559907266965E-01	.642984773359E-01	.871922274344E+00

THETA MATRIX OVER TRAJECTORY ARC 567.01000 TO 593.50000 DAYS
(ALL ELEMENTS ARE IN INTERNAL UNITS)

	CONE ANGLE	CLOCK ANGLE	CONE ANGLE	CLOCK ANGLE
X	.117193817202E+06	-.854963401192E+05	.128013073296E+06	-.656523257663E+05
Y	-.842693910336E+06	.106174905817E+05	-.515100614442E+06	.281829159102E+04
Z	.487386763947E+05	.351719079537E+06	.415816917632E+05	.234326922739E+06
VX	.193977601706E-01	-.418830777692E-01	.118529638005E+00	-.646086396764E-01
VY	-.472953701580E+00	.734787117019E-02	-.524213312769E+00	.260413780846E-02
VZ	.114014821765E-01	.177490758030E+00	.364194383326E-01	.231465353931E+00

ETA MATRIX AT THE TARGET POINT
(ALL ELEMENTS ARE IN INTERNAL UNITS)

	X	Y	Z	VX	VY	VZ
X	.100000000000E+01	0.	0.	0.	0.	0.
Y	0.	.100000000000E+01	0.	0.	0.	0.
Z	0.	0.	.100000000000E+01	0.	0.	0.

TARGET/CONTROL SENSITIVITY MATRIX(3 X 4)
(ALL ELEMENTS ARE IN INTERNAL UNITS)

	CONE ANGLE	CLOCK ANGLE	CONE ANGLE	CLOCK ANGLE
X	.117193817202E+06	-.854960401192E+05	.128013073296E+06	-.656523257663E+05
Y	-.842693910336E+06	.106174905817E+05	-.515100614442E+06	.281829159102E+04
Z	.487386763947E+05	.351719079537E+06	.415816917632E+05	.234326922739E+06

GUIDANCE MATRIX(4 X 3) FOR NONLINEAR GUIDANCE CORRECTION
(ALL ELEMENTS ARE IN INTERNAL UNITS)

	X	Y	Z
CONE ANGLE	-.970358285253E-05	-.262321496051E-05	-.242372719762E-05
CLOCK ANGLE	.106402923632E-05	.720358568247E-06	.223057230509E-05
CONE ANGLE	.158788820007E-04	.275486523740E-05	.401506459331E-05
CLOCK ANGLE	-.239719633034E-05	-.353364444316E-06	.711234166839E-06

ESTIMATED CONTROL CORRECTION FOR ITERATION 2 IN INTERNAL UNITS

	OLD CONTROLS	UPDATES	NEW CONTROLS
CONE ANGLE	.268849133152E+01	.307620976339E-01	.271925339915E+01
CLOCK ANGLE	.140748235433E+01	-.485767457883E-02	.139862447975E+01
CONE ANGLE	.266070744178E+01	-.489520450865E-01	.261117554366E+01
CLOCK ANGLE	.137223486542E+01	.641035755304E-02	.137864522298E+01

CONVERGENCE IN THE NONLINEAR GUIDANCE ALGORITHM AFTER 3 ITERATIONS WITH Q0= .2080E+00

ESTIMATED TRAJECTORY CONDITIONS FOR NONLINEAR TARGETING

ITERATION NUMBER 3

TRAJECTORY STATE AT 593.50000 DAYS(J.D.= 2444550.15478)

	ESTIMATE	REFERENCE	DEVIATION	
X	.684222836733E+03	-.302671830177E+03	.986894666910E+03	KM
Y	.386164455414E+02	-.235964598179E+03	.274581043720E+03	KM
Z	.316746513009E+03	-.184006249666E+03	.500752762675E+03	KM
VX	.203689563321E+01	.204895018934E+01	-.120543561295E-01	KM/SEC
VY	.198112754345E+01	.195337447944E+01	.277530640057E-01	KM/SEC
VZ	.114095298660E+01	.114062787871E+01	.330107892957E-03	KM/SEC
S/C MASS	1443.42622	1443.42539	.00083	KG

TARGET VARIABLES

	ESTIMATE	REFERENCE	DEVIATION	
X	.684222836733E+03	-.302671830177E+03	.986894666910E+03	KM
Y	.386164455414E+02	-.235964598179E+03	.274581043720E+03	KM
Z	.316746513009E+03	-.184006249666E+03	.500752762675E+03	KM

QUADRATIC ERROR FUNCTION TO MEASURE RATE OF CONVERGENCE

Q = .392563366854E+02 FOR ITERATION NUMBER 1
Q = .141729298854E+01 FOR ITERATION NUMBER 2
Q = .208017465996E+00 FOR ITERATION NUMBER 3

PHI MATRIX OVER TRAJECTORY ARC 567.01000 TO 593.50000 DAYS

	X	Y	Z	VX	VY	VZ
X	.126873645734E+01	.145345191837E+00	.392364945859E-01	.233287602406E+07	.130859137711E+06	.349326012976E+05
Y	.144495072475E+00	.132468843632E+01	.414768403366E-01	.130381709155E+06	.232450405291E+07	.382153948373E+05
Z	.422679665135E-01	.395946354417E-01	.904102933016E+00	.365273061225E+05	.372890121511E+05	.223443755403E+07
VX	.532378566716E-07	.154216525917E-06	.414032164953E-07	.104246256484E+01	.205651392708E+00	.543577761324E-01
VY	.159472167490E-06	.560608834040E-07	.473941913855E-07	.208765110281E+00	.109279311542E+01	.651268120572E-01
VZ	.441424904810E-07	.458676393808E-07	-.952780602475E-07	.559874339543E-01	.642803942582E-01	.872036066172E+00

THETA MATRIX OVER TRAJECTORY ARC 567.01000 TO 593.50000 DAYS
(ALL ELEMENTS ARE IN INTERNAL UNITS)

	CONE ANGLE	CLOCK ANGLE	CONE ANGLE	CLOCK ANGLE
X	.137758454219E+06	-.819241440194E+05	.105955778723E+06	-.703017348834E+05
Y	-.636193787240E+06	.112781997459E+05	-.521480607154E+06	.190808636135E+04
Z	.585600216305E+05	.329059602999E+06	.326037923846E+05	.254784562267E+06
VX	.733384376924E-01	-.390634074873E-01	.955154049472E-01	-.692824376515E-01
VY	-.467589251841E+00	.758338367852E-02	-.531937947658E+00	.165717199885E-02
VZ	.169531356268E-01	.166031883319E+00	.270598064233E-01	.252166435066E+00

ETA MATRIX AT THE TARGET POINT
(ALL ELEMENTS ARE IN INTERNAL UNITS)

	X	Y	Z	VX	VY	VZ
X	.100000000000E+01	0.	0.	0.	0.	0.
Y	0.	.100000000000E+01	0.	0.	0.	0.
Z	0.	0.	.100000000000E+01	0.	0.	0.

TARGET/CONTROL SENSITIVITY MATRIX(3 X 4)
(ALL ELEMENTS ARE IN INTERNAL UNITS)

	CONE ANGLE	CLOCK ANGLE	CONE ANGLE	CLOCK ANGLE
X	.137758454219E+06	-.819241440194E+05	.105955778723E+06	-.703017348834E+05
Y	-.636193787240E+06	.112781997459E+05	-.521480607154E+06	.193008636135E+04
Z	.585600216305E+05	.329059602999E+06	.326037923846E+05	.254784562267E+06

GUIDANCE MATRIX(4 X 3) FOR NONLINEAR GUIDANCE CORRECTION
(ALL ELEMENTS ARE IN INTERNAL UNITS)

	X	Y	Z
CONE ANGLE	-.291767657617E-04	-.679303241947E-05	-.714526572348E-05
CLOCK ANGLE	.134704810960E-04	.273019312982E-05	.532862480016E-05
CONE ANGLE	.454115104437E-04	.822084348695E-05	.115624420496E-04
CLOCK ANGLE	-.167328871812E-04	-.313179897596E-05	-.279467871171E-05

ESTIMATED CONTROL CORRECTION FOR ITERATION 3 IN INTERNAL UNITS

	OLD CONTROLS	UPDATES	NEW CONTROLS
CONE ANGLE	.271925339915E+01	.331134584272E-01	.275236685758E+01
CLOCK ANGLE	.139852447975E+01	-.167119288234E-01	.138181255092E+01
CONE ANGLE	.261175543669E+01	-.528635892385E-01	.255889184746E+01
CLOCK ANGLE	.137864522298E+01	.187729728384E-01	.139741819581E+01

COMMANDED THRUST CONTROL CORRECTIONS

THRUST CONTROL CHANGE NUMBER	THRUST CONTROL PHASE NUMBER	THRUST CONTROL TYPE	COMMANDED CHANGE
1	9	CONE ANGLE	7.059005 DEGS
2	9	CLOCK ANGLE	-.822243 DEGS
3	10	CONE ANGLE	-10.267697 DEGS
4	10	CLOCK ANGLE	2.043465 DEGS

ACTUAL THRUST CONTROLS AFTER CORRECTION

THRUST PHASE NUMBER	THRUST PHASE END TIME (DAYS)	THRUST PHASE THROTTLING	THRUST PHASE CONE ANGLE (DEG)	THRUST PHASE CLOCK ANGLE (DEG)	THRUST PHASE CONE RATE (DEG/SEC)	THRUST PHASE CLOCK RATE (DEG/SEC)
8	567.000000	1.354491	129.675246	272.212085	0.000000	0.000000
9	577.000000	.999718	157.696637	79.186321	0.000000	0.000000
10	587.000000	.998981	140.636030	80.061168	0.000000	0.000000
11	600.000000	0.000000	0.000000	0.000000	0.000000	0.000000

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OF POOR QUALITY

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****************************************************************************************************
                                   MONTE CARLO MISSION SUMMARY FOR CYCLE  1
****************************************************************************************************

CP TIME FOR THIS CYCLE =    7.39400 SEC
TOTAL CP TIME USED TO THIS POINT IN EXECUTION =    8.77000 SEC

S/C STATE VECTOR AT TRAJECTORY TIME = 593.50000 DAYS(J.D.=  2444550.15478)
                            ACTUAL              REFERENCE            DEVIATION
                 X     .637993677777E+08   .637952007701E+08   .416700756049E+04  KM
                 Y     .955750007892E+08   .955745797681E+08   .421021105289E+03  KM
                 Z     .240910812142E+08   .240878516603E+08   .322955385387E+04  KM
                 VX   -.398605673393E+02  -.398464859389E+02  -.140814004312E-01  KM/SEC
                 VY   -.667441291828E+01  -.671498459981E+01   .405716915291E-01  KM/SEC
                 VZ   -.436700445979E+01  -.437028247409E+01   .327801430200E-02  KM/SEC

SAMPLED S/C-SEP PARAMETERS
                            ACTUAL              REFERENCE            DEVIATION
  S/C MASS                  1443.65190          1443.42539              .22652  KG

TARGET VARIABLES
                            ACTUAL              REFERENCE            DEVIATION
               X        0.                    -.302671830177E+03   .302671830177E+03  KM
               Y        0.                    -.235964598179E+03   .235964598179E+03  KM
               Z        0.                    -.184006249666E+03   .184006249666E+03  KM

TOTAL DELTA-VELOCITY MAGNITUDE FOR IMPULSIVE MANEUVERS=  0.                KM/SEC
```

3.2.4 REFSEP

The REFSEP sample case provides detailed trajectory print for the Encke flyby mission. A run such as this is likely to be made after the reference trajectory has been determined in TOPSEP and prior to a GODSEP error analysis run. Of particular importance to the GODSEP user is the tracking information which is available over any desired trajectory arc and from which a measurement schedule can be made. The remaining output provides a detailed description of the integration process and the changing geometric relationships among the S/C and the bodies considered.

On the first page of output is a listing of the $TRAJ namelist describing the Encke flyby mission. Except for two of the variables, KARDS and ELVMIN, the input is standard to all the MAPSEP modes. (Other REFSEP peculiar input is described in Section 2.1, Page 12-B of this manual.) The value of KARDS indicates the number of formatted print schedule cards which are to be read during the execution of the REFSEP run. Images of cards (KARDS = 3) may be found immediately after the $TRAJ namelist on the first page. These cards specify the start times, stop times, and time increments for the various print codes. Although many print blocks are scheduled and appear in the sample case output, only <u>one</u> representative print block is included here to illustrate REFSEP's output. The scheduled time is 580 days, at which time the print block includes all possible print options (print code = 1123) which are:

1) nominal trajectory print,
2) primary body data,

3) target data, and

4) tracking data.

Most of the output for each of these options is self-explanatory; however, the tracking calculations deserve additional clarification. The approximate rise and set times of the S/C with respect to the tracking stations (or of the target body with respect to the astronomical observatory) are estimated from the geometry occurring at the scheduled print time. The underlying assumption for these calculations is that the S/C moves very slowly across the celestial sphere. (Hence, these calculations are invalid for a S/C in a near-earth trajectory.) The printed rise and set times are always within one day ($\pm$ 24 hours) of the scheduled print time. These times refer to the time when the S/C rises above or falls below the specified minimum elevation angle (ELVMIN). If the S/C never rises or never sets during the 48-hour span at a particular station, the message "NEVER VISIBLE" or "ALWAYS VISIBLE" is displayed for that station.

```
$STRAJ
 ENGINE = 21.65, 0.65, 21.65,
 ENGINE(11) = 0.64,
 ICOORD = 3,
 NM = 3*10,
 NLP = 3,
 NTP = 19,
 SCMASS = 1988.0,
 STATE = -5.9211044SE3,
 2.1671464953E3,
 1.81746472E3,
 -6.9455773,
 -2.5761073,
 -7.33123375,
 TLNCH = 2443955.65478,
 TEN=593.6987, ISTOP=1,
 THRUST =
 9.,54.,3*0.,
 1.,145.,1.,58.1,224.6,5*0.,
 1.,235.,1.,75.,252.,5*0.,
 1.,470.,1.,85.334,269.,5*0.,
 1.,525.,1.,120.501,268.742,5*0.,
 1.,567.,1.355,130.432,272.53,5*0.,
 1.,577.,1.,150.64,80.,5*0.,
 1.,587.,1.,165.,77.59,5*0.,
 9.,805.,8*0.,
 MODE = 4,
 KARDS=3,
 PLVMIN=15.,
 $

0.0        60.0       5.0             1012
50.0       600.0      50.0              23
525.0      690.0      5.0             1123
```

TRAJECTORY INITIALIZATION

INITIAL EPOCH (REFERENCE DATE)
JULIAN DATE 2443956.6547800004
CALENDAR DATE .... 1979 MAR 24 3 HR 42 MIN 52.9920 SECS
TRAJECTORY START EPOCH 0.0000000000 DAYS AFTER THE INITIAL EPOCH
JULIAN DATE 2443956.6547800004
CALENDAR DATE .... 1979 MAR 24 3 HR 42 MIN 52.9920 SECS
TRAJECTORY END EPOCH 593.4987000000 DAYS AFTER THE INITIAL EPOCH
JULIAN DATE 2444550.1534799937
CALENDAR DATE .... 1980 NOV 6 . 15 HR 41 MIN .6714 SECS

INITIAL STATE VECTOR AT 0.0000000000 DAYS AFTER THE REFERENCE EPOCH

	X	Y	Z	MAGNITUDE
POSITION	-.59211044500000E+04	.21671469800000E+04	.18174047200000E+04	.65619329360342E+04
VELOCITY	-.69456773000000E+01	-.85261078301000E+01	-.73312337500000E+01	.13216803507298E+02

SEPS MASS 1988.0000000000 KG
EXHAUST VELOCITY 29.4180000000 KM/SEC
ELECTRIC POWER AT 1 A. U. 21.6500000000 KW
THRUSTER EFFICIENCY .6400000000
RADIATION PRESSURE COEFFICIENT -1.0000000000

LIST OF GRAVITATING BODIES
SUN
EARTH
ENCKE
TARGET PLANET IS ENCKE

INTEGRATION STEP FACTOR .0500

REFERENCE THRUST CONTROLS

THRUST PHASE NUMBER	THRUST PHASE END TIME (DAY)	THRUST PHASE THROTTLING	THRUST PHASE CONE ANGLE (DEG)	THRUST PHASE CLOCK ANGLE (DEG)	THRUST PHASE CONE RATE (DEG/SEC)	THRUST PHASE CLOCK RATE (DEG/SEC)	NUMBER OF THRUSTERS
1	64.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2	140.000000	1.000000	68.100000	224.600000	0.000000	0.000000	0.000000
3	230.000000	1.000000	75.000000	252.000000	0.000000	0.000000	0.000000
4	470.000000	1.000000	85.374000	269.000000	0.000000	0.000000	0.000000
5	525.000000	1.000000	120.501000	268.742000	0.000000	0.000000	0.000000
6	567.000000	1.350000	130.432000	272.530000	0.000000	0.000000	0.000000
7	577.000000	1.000000	150.640000	80.000000	0.000000	0.000000	0.000000
8	587.000000	1.000000	165.000000	77.590000	0.000000	0.000000	0.000000
9	600.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000

BODY PARAMETERS AND ORBITAL ELEMENTS HAVE BEEN READ-IN FOR ENCKE AT JULIAN DATE....2444580.000000000000

PLANET RADIUS	.50000000000000E+03 KM			
PLANET SPHERE	.10000000000000E+04 KM			
PLANET GRAVITATIONAL CONSTANT	.10000000000000E-08 KM**3/SEC**2			
SEMI-MAJOR AXIS	.33180812670000E+09 KM	0.		KM/JC
ECCENTRICITY	.84700000000000E+00	0.		1.0/JC
INCLINATION	.11950000000000E+02 DEG	0.		DEG/JC
ASCENDING NODE	.33423000000000E+03 DEG	0.		DEG/JC
OMEGA-T	.16020000000000E+03 DEG	0.		DEG/JC
MEAN ANOMALY	0. DEG	0.		DEG/JC

DETAILED PRINT EVENT SCHEDULE

FROM 0.00000 DAYS TO 60.00000 DAYS IN INCREMENTS OF 5.00000 DAYS -- CODE NO. 1012
FROM 50.00000 DAYS TO 593.49870 DAYS IN INCREMENTS OF 50.00000 DAYS -- CODE NO. 23
FROM 525.00000 DAYS TO 593.49870 DAYS IN INCREMENTS OF 5.00000 DAYS -- CODE NO. 1123

(CORE REQUIRED FOR THIS JOB, 250200 OCTAL)

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JULIAN DATE -- 2444536.6547690D CONTROL PHASE -- 6 PRIMARY BODY -- SUN
DAYS FROM LAUNCH- 590.00000000 PRESENT S/C MASS- 1462.20176727 KG EPHEMERIS BODY -- ENCKE
DAYS FROM CUTOFF- 13.4987000 POWER AVAILABLE-- 21.00000000 KW TARGET BODY -- ENCKE

S/C RELATIVE STATES		X	Y	Z	MAGNITUDE
SUN	POSITION	.10673568760378E+09	.99112073584481E+08	.28015396436489E+08	.14832604363329E+09
	VELOCITY	-.33909328484282E+02	-.99751901086138E-02	-.25272715788664E+01	.34003375650105E+02
EARTH	POSITION	-.20926921260286E+08	.22715580508167E+08	.28015396436489E+08	.41698873711201E+08
	VELOCITY	-.18126719958327E+02	-.25462781285096E+02	-.25272715788664E+01	.31357906649640E+02
ENCKE	POSITION	-.26038996281404E+07	-.23797073379350E+07	-.13953833587053E+07	.37934649026662E+07
	VELOCITY	.25089960478863E+01	.22308734011179E+01	.12543660775914E+01	.35840328622759E+01

S/C ACCELERATIONS	X	Y	Z	MAGNITUDE
PRIMARY BODY	-.43408027678277E-05	-.40307526643496E-05	-.11393479093436E-05	.60322176161730E-05
PERTURBING BODIES	.10081805879761E-09	-.13577608213469E-09	-.15590915563661E-09	.23001541311591E-09
THRUST	-.53702677306462E-06	-.26311465951795E-06	-.14613936804528E-06	.62485754183147E-06
RADIATION PRESSURE	0.	0.	0.	0.

INDIVIDUAL PERTURBING ACCELERATIONS	X	Y	Z	MAGNITUDE
EARTH	.10081805879756E-09	-.13577608213474E-09	-.15590915563663E-09	.23001541311594E-09
ENCKE	.47668640608291E-22	.43563915604522E-22	.25553075004343E-22	.69446352762537E-22

PLANETARY EPHEMERIDES		X	Y	Z	MAGNITUDE
EARTH	POSITION	.12766280886407E+09	.76396493075814E+08	0.	.14877572692249E+09
	VELOCITY	-.15782605525955E+02	.25452806095587E+02	0.	.29948859383873E+02
ENCKE	POSITION	.10533978723192E+09	.10149177692742E+09	.29410779795195E+08	.15205513415519E+09
	VELOCITY	-.36418221532169E+02	-.22408485912566E+01	-.37816376566578E+01	.36682643429765E+02

INTEGRATION DATA, ENCKE FORMULATION		X	Y	Z	MAGNITUDE
CONIC	POSITION	.10673807905407E+09	.99113190664139E+08	.28015993688142E+08	.14832848006144E+09
CONIC	VELOCITY	-.33866014828461E+02	.15185076959170E-01	-.25139955767493E+01	.33959401307129E+02
DELTA	POSITION	-.21914502865817E+04	-.11170757579164E+04	-.59745165274051E+03	.25312569844906E+04
DELTA	VELOCITY	-.48510663821009E-01	-.25160267078334E-01	-.13312001917133E-01	.56245292592801E-01
DELTA	ACCEL	-.22549243651695E-10	-.28895727734406E-09	-.18775240529192E-09	.34542849460388E-09

RECTIFICATIONS 109
INTEGRATION STEPS 213
STEP SIZE (DAYS) .... .18752763299048E+01

- OSCULATING CONIC DATA -

OSCULATING CONIC - ELLIPSE

	X	Y	Z	MAGNITUDE
PERIPOINT VECTOR	-.48508276258242E+08	.13915212907470E+08	-.10071132667742E+07	.50620445777485E+08
PERI-VEL VECTOR	-.16797693345766E+02	-.64224984744768E+02	-.14254229638151E+02	.67896411099092E+02

UNIT VECTOR DIRECTIONS	X	Y	Z
P-VECTOR	-.95817632474495E+00	.27711375527754E+00	-.19895385180945E-01
Q-VECTOR	-.24739445824903E+00	-.94589819857548E+00	.20993465690011E+00
W-VECTOR	-.74798097000272E-01	-.15791188640F33E+00	.97751297356134E+00
NODE-VECTOR	.93852974927627E+00	-.34520923792117E+00	0.
POSITION	.71966314498429E+00	.66820412081161E+00	.18887712311455E+00
VELOCITY	-.99723409311822E+00	-.29335881854406E-03	-.74324137824064E-01

CONIC ELEMENTS	A	E	INC	NODE	APS	MA	TA
S/C WRT PRIMARY	.2059768E+09	.7584635E+00	.1217365E+02	.3318054E+03	.1854137E+03	.3327652E+03	.3129585E+03

----- TARGET DATA -----

SUN-TARGET-S/C ANGLE 10.438510412547 DEG
EXHAUST-LINE OF SIGHT 15.990595170040 DEG
S/C-TARGET UNIT VEC .66641721880972E+00 .62731655597035E+00 .36783874228665E+00

OSCULATING CONIC DATA WRT TARGET BODY

OSCULATING CONIC = HYPERBOLA

ECI = .48181625197323E+05 F = .99516751473925E-01 RCA = .87176588561291E+05
BDR = .72860910129607E+05 T-ATM = .56464019399791E+02 VCA = .35840328622759E+01
VHP = .35840328622759E+01 TSOI = .59224716689083E+03 TCA = .59224716689083E+03

VHP-VECTOR .... .25089960476862E+01 .22308734011478E+01 .12543660779913E+01 .35840328622759E+01
B-VECTOR .... .51007653050606E+05 -.19093004760263E+05 -.68069346280064E+05 .87176588561292E+05
PERIPOINT VECTOR .51007653050600E+05 -.19093004760263E+05 -.68069346280064E+05 .87176588561291E+05
PERI-VEL VECTOR .25089960476862E+01 .22308734011479E+01 .12543660779914E+01 .35840328622759E+01

CONIC ELEMENTS	A	E	INC	NODE	APS	MA	TA
S/C WRT TARGET	-.7764954E-10	.1119839E+16	.5883396E+02	.2858209E+02	.2941433E+03	-.4871529E+17	.2713168E+03

----- TRACKING DATA -----

SUN-EARTH-S/C ANGLE 64.491881952770 DEG
RANGE-VEL INCLUDED ANGLE 101.910636740869 DEG
GEOCENTRIC EQUATORIAL DEC 56.419721888360 DEG
RIGHT ASCENSION 155.141311179695 DEG
EAST LONGITUDE 68.717152711647 DEG
GREENWICH HOUR ANGLE 88.424158466048 DEG

MINIMUM ELEVATION ANGLE............... 15.000 DEG

STATION	RISE	SET	ELEVATION	AZIMUTH	RANGE	RANGE RATE
1	579.17954	579.84286	1.84457	358.03624	.41698667914532E+08	-.64571075454193E+01
2	579.62954	580.56042	42.95567	45.39343	.41694527677929E+08	-.86529701749395E+01
3	NEVER	VISIBLE	-24.96511	322.78856	.41701565403267E+08	-.62680260354068E+01

ASTRONOMICAL DATA FOR THE TARGET BODY

GEOCENTRIC EQUATORIAL DEC 59.771506541781 DEG
RIGHT ASCENSION 142.283547265221 DEG

STATION	RISE	SET	ELEVATION	AZIMUTH	RANGE	RANGE RATE
9	ALWAYS	VISIBLE	19.07596	5.38194	.42782261848846E+08	-.10030710566068E+02

4.0 OPERATING GUIDELINES

This chapter is intended to provide useful operating guidelines for MAPSEP. It is assumed that the user has (1) some knowledge of the methods (Volume I, Analytical Manual), input variables (Volume II, Chapter 2) and output (Volume II, Chapters 3 and 5), and (2) a particular analysis application. Among the latter possibilities, for example are:

- time history relationships of the spacecraft, Earth and target body;
- generation of an integrated trajectory meeting mission requirements;
- trajectory sensitivity to selected parameters;
- trajectory dispersions and their propagation effects;
- ground based and on-board navigation requirements;
- thrust control authority and thrust accuracy requirements;
- trajectory and system estimation accuracies;
- evaluation of dynamic and measurement error sources;
- mission strategy evaluation;
- probabilities of mission success or science return.

Many of these applications in terms of MAPSEP operation will be discussed in the following sections.

It is clear that MAPSEP has a sizeable amount of input in order to be flexible in its analysis capability. However, only a small segment of input is often used at any one time. The question of where these input values come from is problem dependent. For example,

if MAPSEP is used as part of a Phase B system design process, then TOPSEP would be operated first to generate one or more integrated reference trajectories for the baseline configuration(s), GODSEP would be used parametrically to examine the effects of various levels of error sources on the system and trajectory, and SIMSEP would be operated sparingly to evaluate specific error values. The initial trajectory values, e.g., specific impulse, launch velocity and mass, power levels, etc. would be obtained from the mission analysts who performed mission opportunity searches. Earth based navigation characteristics (including their respective error sources) would be obtained from operational tracking networks. Thrust performance and other on-board characteristics, and uncertainty levels, would be obtained from the respective subsystem areas. Guidance success zones and mission strategy would depend primarily on science or other mission objectives. Unfortunately, many of the input values are not received in forms that are directly usable. A small amount of preparatory analysis and supplementary software is often needed. This requires knowledge both of the subsystem where the data originated and of MAPSEP. A reverse problem also exists, namely, how to translate MAPSEP results into information needed by other subsystems. Thus, operating MAPSEP effectively is considerably more involved than just being familiar with the input and output.

The common element of all mode usage is the $TRAJ namelist which describes the nominal trajectory. The required input of $TRAJ contains as a minimum the variables

TLNCH, TEND, STATE, SCMASS, THRUST, ENGINE, STEP, ICØØRD, ISTØP, NTP, NB, MØDE,

with other parameters being optional. In the following sections, it is assumed that the basic $TRAJ has been input, except as noted. Each mode is then treated as a separate program, which is true for most MAPSEP applications.

4.1 Trajectory Generation - TOPSEP

There are four basic applications of the TOPSEP mode: (1) trajectory propagation, (2) trajectory grids, that is, a matrix of trajectories corresponding to different control parameter steps (3) trajectory targeting to meet mission objectives, and (4) trajectory targeting and optimization. These submodes are often used in sequence to eventually obtain an optimal low thrust trajectory. They can also be used independently, for example, to generate a time history of Earth-Sun-vehicle-target body relative geometries for a baseline mission. Each submode or TOPSEP option is defined by parameters in the namelist $TØPSEP which is input directly after $TRAJ.

The most common usage of TOPSEP is in generating a targeted trajectory with system constraints reflecting a proposed spacecraft and mission. Final mass optimization is generally not used because most low thrust trajectories have relatively flat performance curves in the local area of interest.

The targeting (and optimization) procedure begins with an initial guess of the trajectory controls: initial state and mass, thrust

segments including duration, thrust magnitude and pointing, and vehicle characteristics including specific impulse, base power level, thruster efficiency, etc. These inputs are put in $TRAJ. The initial guess is often a combination of engineering intuition and results from a mission opportunity search program, for example, QUICKTOP (Ref. 8) for interplanetary missions and POST (Ref. 9) for near-Earth missions. The value of a reasonably accurate initial guess cannot be overemphasized. The targeting process for low thrust trajectories is often so non-linear that many iterations are spent just to bring an initial guess into the "ball park".

Assuming that a bad initial guess occurs, which is generally the case, then many single trajectories are computed for various values of initial coast time, thrust direction and magnitude in dominant thrust phases, power level, etc. One or more trajectories are selected from this semi-random collection to start the targeting submode. An alternate, or supplementary, technique is to apply the grid submode. This permits a somewhat more organized search for acceptable trajectories and also reveals the extent of nonlinearity in the control vs. target error hyperspace. In any case, the integration step size factor should be set to a large value, e.g., STEP = 1., to minimize run time and cost because many trajectories may have to be examined before a satisfactory one is reached.

The initial guess selection represents the zeroth level of a targeting strategy. Thereafter, the targeting submode is entered

and the strategy is to stabilize the targeting process and prevent divergence. An example of a targeting strategy for an interplanetary mission is Table 4-1 (specific numerical examples can be found in the sample case of Section 3.2.1). The first level varies initial conditions, segment times and control parameters in the early thrust (and coast) phases such that the spacecraft reaches the general vicinity of the target body with not unreasonable target conditions. The second and third levels then successively refine the control parameters and trajectory accuracy until all desired target conditions are met within tolerance. Thereafter, optimization with respect to final mass may be performed if desired.

LEVEL	STEP SIZE (STEP)	CONTROL PARAMETERS		TARGET PARAMETERS	
		TYPE	SENSITIVITY TO TARGETS	TYPE	TOLERANCES
0	Large	Initial Conditions, Early Segments	High	All	Very Loose
1	Medium	Initial Conditions, Early Segments	High	Helio-Centric	Loose
2	Medium	Early and Intermediate	High-Medium	Target Centered	Loose
3	Small	Intermediate and Late	Medium-Low	Target Centered	Tight

TABLE 4-1 Interplanetary Targeting Strategy

It is apparent that every mission will have a different effective targeting strategy depending upon the initial guess and mission type (interplanetary vs. near-Earth, flyby vs. rendezvous, inbound to the sun vs. outbound, etc.). Furthermore, there is a considerable amount of user decision making and intuitive reasoning that is required. The unfortunate result is that the targeting process becomes less mechanical and more subjective.

4.1.1 Trajectory Propagation

The simplest TOPSEP application is propagation of a single trajectory for spacecraft ephemeris information. In addition to the trajectory parameters in $TRAJ with MØDE = 1 (See Section 4.0), the required $TØPSEP parameters are IMØDE = 1 and MPRINT(1) equal to the appropriate print option.

4.1.2 Trajectory Grid

As mentioned earlier, the uses of a trajectory grid can be (1) searching for a reasonable initial trajectory to start the targeting submode, (2) investigating the non-linearity of the hyperspace containing control and target parameters, (3) determining appropriate perturbing step sizes in control parameters for numerical differencing, or (4) any combination of these.

The grid submode in TOPSEP requires only a few more parameters in $TØPSEP than the simple trajectory propagation. These are IMØDE = 3, H(I,J) = perturbation from the nominal for the I, J control parameter, HMULT = scale factor of perturbations for second step, and MPRINT(1) equal to the appropriate print option.

For example, an input of H (2, 2) = 2., H (8, 21) = .01, HMULT = 2., -.5, would result in the display of five trajectories: (1) the nominal, (2) nominal with duration of second thrust phase extended by two days, (3) nominal with duration of second thrust phase extended by four days, (4) nominal with initial velocity magnitude increased by .01 Km/sec, and (5) nominal with initial velocity magnitude decreased by .005 Km/sec.

If more than two steps in each control direction are desired, it is a simple matter to stack cases. The organization of the input deck is as follows. After the first case ($TRAJ and $TØPSEP namelists) each succeeding case requires only a $TØPSEP namelist with the appropriate changes to H and HMULT. To cycle back to the TØPSEP data overlay the parameter MØDE must be set to -1 in the $TRAJ namelist. The main overlay will not be re-entered; thus, the run will be terminated after the last $TØPSEP namelist. Any additional $TRAJ namelists will be skipped in the search for $TØPSEP namelists. If the user wishes to adjust the nominal trajectory for any of the subsequent stacked cases (i.e., add thrust phases, extend or reduce phase durations, change cone and clock angles, etc.) MØDE must be set to 1 in the first $TRAJ. Each of the following stacked cases consists of pairs of $TRAJ and $TØPSEP namelists. The user should realize, of course, that any inputs, which are not explicitly reset, maintain their last value in succeeding cases.

4.1.3 Trajectory Targeting

The primary purpose of the TOPSEP mode is to generate an

integrated trajectory which fulfills a given set of mission constraints while minimizing fuel expenditure (or maximizing deliverable payload). By far the most difficult part of trajectory generation is the targeting process. Non-linearities in trajectory dynamics often wreak havoc with the linear methods used in both targeting and optimization. This is especially true for interplanetary low thrust trajectories with an inaccurate initial guess. It is highly recommended that the user familiarize himself with Chapter 5 of the MAPSEP Analytic Manual, and continually refine his targeting strategy depending upon the results of each iteration.

Input for a TOPSEP targeting run consists of the namelists $TRAJ and $TOPSEP. The $TRAJ variables define the reference trajectory and serve as the initial guess (zeroth iterate) for the run. The $TOPSEP namelist defines the targeting strategy. Those parameters which are used to alter the initial trajectory in the TOPSEP mode are described below.

- IMØDE = 2 specifies the targeting (and optimization) submode.
- IASTM = 1 refers to the augmented state transition method of targeting. The sensitivity matrix, which is necessary to compute the control correction, is calculated from the integrated STMs. Selection of this option precludes the optimization process and also requires that the trajectory be terminated on final time (ISTØP = 1 in $TRAJ). The set of controls is restricted when STM targeting is used. The controls which may be selected are: 1) the initial state (x, y, z, $\dot{x}$, $\dot{y}$, $\dot{z}$); 2) thrust phase end time; 3) throttling; 4) cone angle; and 5) clock angle. If IASTM = 0 numerical differencing techniques are applied

to compute the sensitivity matrix. This targeting procedure requires more computation time; however, there is no restriction on the set of controls which may be selected.

- o Non-zero values in the H array denote active control parameters. In addition, when IASTM = 0 the values of H represent the control perturbations to be used in constructing the sensitivity matrix. For example, if H(4, 21) = 10., H (2, 1) = .1, H (4, 5) = .5 are input, then there will be three active control parameters: initial position magnitude, phase end time of the first thrust phase and thrust cone angle of the fifth phase. The perturbations used to construct sensitivity matrices will be 10 Km., .1 days and .5 degrees, respectively.
- o ULIMIT are the minimum and maximum bounds, if any, on the control parameters. ULIMIT can be used not only to impose hardware related constraints, but also to modulate the targeting process. Used in conjunction with PCT, ULIMIT insures that control corrections will not be unacceptably large. Also, proper usage of ULIMIT will restrict controls such as phase end times from drifting through any other set phases.
- o IWATE determines the type of weighting scheme to be applied to the control parameters. The most frequently used values of IWATE in order are:
  - oo IWATE = 2 for normalized control weighting when very little or no information about the targeting problem is present and when controls with

different units are used simultaneously. This is also valid when all the controls are thrust phase times, and normalization is still according to the magnitude of the controls.

- oo IWATE = 1 when the user has gained experience with the specific targeting problem and can select his own weights.

- o UWATE are control weightings which scale the basic weighting scheme specified by IWATE. The relative weights among the control parameters impact the targeting process.

In general, weights should be smaller for controls earlier in this mission than for similar control parameters in later mission phases to account for diminishing target sensitivities to controls in these latter phases.

- Non-zero values in the TARTØL array denote active target parameters and their tolerances, analgous to the H array for control parameters.
- TARGET contains the desired values of the active target parameters.
- JWATE is used to "normalize" the target variables by dividing by their respective tolerances; this is especially helpful in determining linear control dependency (See STØL) when different types of target variables are used, e.g., position and velocity or time of flight and closest approach distance.
- STØL is used in linear dependency tests, that is, if two (or more) control parameters have the same effect on the target parameters, as measured by a vector inner product test of the appropriate columns of the sensitivity matrix, then at least one of the dependent control parameters is deactivated for the current iteration. STØL is the sine of the minimum acceptable "angle" between the column vectors of the sensitivity matrix and is highly sensitive to the control weights and target tolerances. If no target weighting is employed (JWATE = 0), then STØL should be quite small, for example STØL = 1.E-6; otherwise, STØL should be about .001. STØL can also be used to terminate a targeting run after the

sensitivity matrix has been computed and before any trial trajectories are taken (STØL=1).

- PCT determines what fraction of the target error should be eliminated for the current iteration and scales the control correction accordingly; if the targeting porcess is very non-linear, then the sensitivity matrix (used to compute control corrections) is valid only over small regions around the nominal, and PCT should be set to a small level, e.g., PCT = .1; on the other hand, a full control step (PCT = 1.) will attempt to remove all the target error at once which is effective only for relatively well-behaved (linear) problems.
- NMAX is the maximum number of iterations which is typically set to less than 3 so that the targeting process can be continually monitored and the targeting strategy can be changed accordingly.

The parameters H, ULIMIT, IWATE, UWATE, TARTØL, TARGET, JWATE, STØL, PCT and NMAX generally provide the most significant effects and are the most often used parameters in the adaptive targeting process. However, there are also a number of options which are very helpful in stabilizing or accelerating convergence of the targeting process under certain conditions.

- BTØL is used in conjunction with the control constraints (ULIMIT) to define a marginal area near control boundaries. If a control lies in this area and a control correction is

made to the ULIMIT boundary, a modification is made to the iteration process. The control on the bound is made inactive and a control step using the remaining controls is computed from the modified performance gradient and sensitivity matrix without incrementing the iteration counter. If the control is in the feasible region but not in the tolerance region and a control correction is made to the boundary, the control is also made inactive; however, a new performance gradient and sensitivity matrix are computed for the next step.

- EPSØN determines what action is to be taken if all the trial trajectories are worse than the reference in terms of the quadratic target error index. If EPSØN is zero, the run is terminated; if EPSØN is non-zero, it is assumed that the sensitivity matrix is invalid and a new sensitivity matrix is computed using the reference trajectory and new control perturbations (the old values (H) scaled by EPSØN). The trial trajectory process is then repeated. EPSØN is used to compute a more well-behaved sensitivity matrix by changing secant partials to tangent partials, or vice versa, depending upon the strategy.
- GTRIAL are the one-dimensional search constants, which are used to find the minimum target error (or cost index) in the $\Delta \underline{U}$ direction. They are useful tools to restrict the search in the $\Delta \underline{U}$ direction depending upon the level of the targeting search (refer to Table 4-1).

- oo GTRIAL(1) is most useful in restricting the percentage decrease in the size of the control scale factor from the preceding estimate.
- oo GTRIAL(2) restricts the scale factor estimate to a maximum allowable value.
- oo GTRIAL(3) is a minimization tolerance on the control scale factor. A "loose" tolerance value of .1 will cause the search to terminate if the estimated control scale factor is within 10% of the preceding value. A "tight" tolerance of .01 or less may result in the use of all of the possible polynominal curve fits in the $\Delta \underline{U}$ direction since convergence is based upon a 1% difference in two successive scale factor estimates.
- oo GTRIAL(4) has a similar control on the search as GTRIAL(3). The factors which are compared are the estimate and actual values of the index to be minimized. If GTRIAL(4) is relatively small ($<$ .01) it is likely that more trial steps will be taken per iteration than if the tolerance is "loose" ($>$ .1).
- oo GTRIAL(5) restricts the extent of the search in the $\Delta \underline{U}$ direction. The maximum value is 4 which indicates that all four curve fitting techniques may be used if convergence is not realized up to the fourth fit (e.g., two-point-one-slope fit, three-point-one-slope fit, three-point fit, four-point fit).

- An option that can save significant computer time is the ability to input the target sensitivity matrix S and performance gradient G, by setting INSG = 1 in $TØPSEP, instead of computing S and G internally. This might be done, for example, if (1) a previous run computed a sensitivity matrix, but neither the trial trajectories nor a control correction were implemented, or, (2) the number of controls and/or targets were to be changed (the input G and S would be composed of elements from previous G and S matrices) assuming the reference trajectory has not been changed (much), or (3) a sensitivity matrix is available from some other program or method.
- DFMAX is used to restrict increases in the cost index (negative of payload) associated with a targeting step. For example, if a targeting control correction reduces the target error but also reduces the SEP payload more than the DFMAX specification the control correction will be appropriately scaled.

The targeting process can best be illustrated by a simple example. Figure 4-1 is a diagram of control parameter space (U_1, U_2) with contours of constant target error (T_5 T_4 ... T_o). Target contours are a strong function of the particular types of target and control parameters, and are often very non-linear. The outer dashed lines represent control constraints (ULIMIT) and the region between the inner and outer dashed lines represent the "marginal" area. The starting point or initial guess lies at $U_2 = 0$ and the boundary U_1 = ULIMIT(1, 2). The eventual point of convergence is near one of two possible minima and on the boundary U_2 = ULIMIT(2, 2). Convergence to a local minimum and not to a point of zero target error is generally the case rather than the exception even though there are more

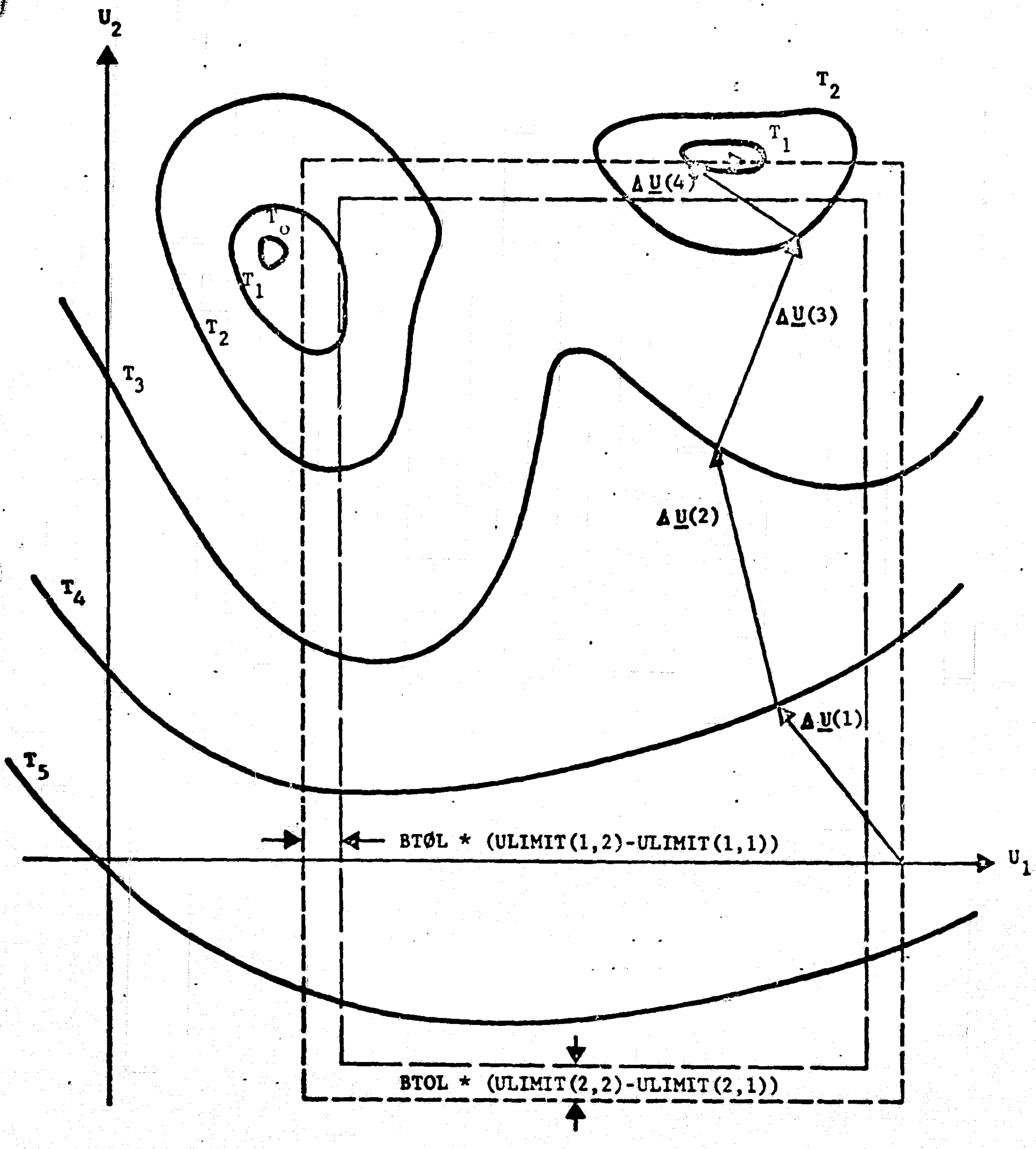

Figure 4-1. Example of Targeting Process

controls than target parameters. The control correction steps $\Delta \underline{U}(1), \ldots, \Delta \underline{U}(5)$ represent the results of five corresponding iterations of TOPSEP, each one of which includes computation of the sensitivity matrix and trial trajectories. Note that $\Delta \underline{U}(3)$ resulted in controls which lie in the feasible region but outside the marginal area, and the next iteration $\Delta \underline{U}(4)$ resulted in contact with the U_2 boundary. The next iteration $\Delta \underline{U}(5)$ moved along the U_2 boundary to the point of minimum target error. If $\Delta \underline{U}(3)$ had ended up within the marginal area, but not necessarily on the U_2 boundary itself, then the BTØL logic discussed above would be exercised.

Although the control corrections appear to be orthogonal to the target error contours, this is not always the case (except in a small region near the reference control point of each iteration). The control parameter weights (UWATE) and basic weighting scheme (IWATE) are used to alter the shape of the general contours such that the control correction is applicable over a wider control area, rather than the localized area near the reference point. Indeed, a more accurate representation of the contours and targeting process would be in "weighted" space, that is, control and target parameters divided by their respective weights. In weighted space, wherein the control corrections are actually computed, contours might look completely different. Furthermore, the test of linear dependency (STØL) between control parameters takes on a more obvious geometrical significance because the weighted control and target parameters are not so dependent upon units (seconds vs. days, radians vs. degrees, etc.) or mission segment (early vs. late).

The targeting strategy can be reduced to choosing appropriate control and target parameters and their weights. Because of this, targeting is more an art than a science. Furthermore, a good initial guess is required to minimize computer time and "artistic" effort.

4.1.4 Trajectory Optimization

When a trajectory has been found which meets, or nearly meets, desired targeting conditions, TOPSEP can be used to refine the trajectory and maximize payload. However, this option is rarely used because by the time a targeted trajectory has been computed which also meets the varied constraints of the mission and S/C system, there is little perf rmance left to optimize. It is probable of course that only a local optimum has been reached, but to find another local optimum (much less the global optimum) requires untargeting the trajectory, at least temporarily, to reach a signif- i antly different point in control vs. performance space.

The optimization problem is similar to that illustrated previously in Figure 4-1 where target error contours are replaced by performance contours. A significant difference, however, is that the starting point is already very close to the (local) optimum.

The inputs to $TØPSEP for optimization include all of those required for targeting, in addition to

- ØSCALE, used to establish the relative weighting between net cost (See Analytic Manual) and target error for simultaneous optimization and targeting; that is, the parameter to be minimized is the sum of net cost,

multiplied by ØSCALE, plus the quadratic target error; note that the quadratic target error depends upon both the actual target error and their tolerances, and it is close to or less than one for a reasonably targeted trajectory.

- TUP is the boundary of quadratic target error above which targeting only is performed and below which simultaneous targeting and optimization occurs.
- TLØW is the boundary of quadratic target error above which simultaneous targeting and optimization occurs and below which optimization only is performed.
- DP2 is a constant which is used to scale the optimization correction relative to the constraint correction. Thus, the user is capable of restricting optimization control corrections which introduce large target errors. (Analytic discussion in Reference 1, page 50.)

Previous experience has shown that optimization of low thrust interplanetary trajectories is generally futile, once targeted conditions have been reached.

4.2 Linear Error Analysis - GODSEP

The linear error analysis mode provides a relatively quick evaluation of trajectory errors due to anticipated system and environmental uncertainties. There are several analysis techniques available within GODSEP depending upon the mission segment, affected systems and desired analysis depth. The most common options are (1) generation of trajectory and state transition matrix data related to a selected reference trajectory and storing the data on disc and/or tape, the STM file, (2) a covariance analysis about some portion or all of the reference trajectory using data on the STM file, (3) a combined STM file generation and covariance analysis in a single run, (4) an evaluation of error source mismodeling effects (generalized covariance) based upon a previous covariance analysis (which assumed perfect modeling), and (5) a covariance analysis of the reference trajectory using integrated covariances (PDOT) instead of the transition matrix methods.

Whatever option is chosen, the namelist $GØDSEP must be input directly after $TRAJ to specify necessary parameter values. Other input features are optional, for example, specification of STM and/or GAIN files, input of namelist $GEVENT for guidance events, and input of fixed field cards containing measurement event and propagation event data.

A typical error analysis needs as input (1) an integrated reference trajectory, (2) expected dynamic and navigation error sources, (3) a guidance and navigation strategy, and (4) system constraints.

tolerances and evaluation criteria. The reference trajectory is obtained from TOPSEP as discussed in the previous section. Both expected error source levels and the guidance and navigation strategy are related to mission objectives and subsystem characteristics. Strategy includes the type and density of observations used in navigation, both on-board and ground based, orbit determination (OD) method, and the type and frequency of guidance updates.

System constraints and tolerances can be defined a-priori or can be determined as part of the error analysis. Generally, some baseline requirements are established and the error analysis either confirms them or points out needed changes. Another criterion for evaluation of trajectory errors is the guidance success zone. This is the region of acceptable terminal error as determined by minimum science return and/or by post encounter requirements.

In terms of MAPSEP and GODSEP operation, once a trajectory has been defined by TOPSEP, that is, initial state vector, thrust/coast segment times, thrust controls, etc., then the linear error analysis begins with generation of an STM file. The STM file is created by propagating the reference trajectory and writing, on disc, state transition matrix and trajectory related data at specified epochs. The STM file can be saved on tape for permanent storage such that subsequent analyses do not need to regenerate the reference data. This is often the case for a parametric examination of error sources and mission strategies.

Once an STM file is created, GODSEP can be operated in the

standard covariance mode. That is, a-priori covariances (control and knowledge) are propagated using transition matrices, off the STM file, from one event to the next. At each event the control and/or knowledge covariance is modified. For example, at a measurement event, observation matrices and a filter gain are computed, then the knowledge covariance is updated to reflect the new trajectory estimate (non-deterministically). The only exceptions where a covariance is not modified at an event are eigenvector (for instantaneous covariance display) and prediction (for display of a future covariance assuming no further measurements or guidance). Thus, a time history of expected uncertainties in actual (control) and estimated (knowledge) parameters is computed as the sequence of mission events unfolds.

In the course of a system design, the standard covariance analysis is run many times with varying levels of error sources, measurement schedules, guidance policies, etc. At some time, however, certain key assumptions should be evaluated. One of these assumptions is the effective process noise model which is an integral part of covariance propagation using transition matrices. The PDOT option in GODSEP permits a more realistic (in a mathematical sense) evaluation of thrust process noise by integrating a state covariance explicitly. The state is augmented by parameters which characterize the noise process. Correlations between thrust noise and other parameters, dynamic and measurement, are computed as part of the PDOT covariance propagation. This is in direct contrast to the standard

covariance analysis where these correlations are assumed to be zero. In many cases, these correlations will be small, but in some mission phases they may contribute significantly to the error analysis results.

The PDOT option does not use the STM file, but is more costly to run than STM file generation and a standard covariance analysis combined, primarily because of the augmented state. Furthermore, because of its support role, no guidance or prediction events are allowed in PDOT.

A second assumption in the standard covariance analysis is that all process characteristics and expected performance deviations are known. That is, the OD algorithm assumes that uncertainties in dynamic and measurement parameters are perfectly described by input levels. If the true uncertainty in any parameter is different from that assumed by the OD process, the error analysis results may be invalid. Verifying error analysis results can be done by simulation (See SIMSEP description) but this can be expensive. So, an alternative verification technique is provided in the error analysis mode, called generalized covariance.

The importance of parameter mismodeling is not just knowing that it exists -- it will always be impossible to model the real world exactly -- but also knowing what its impact is on the error analysis. To determine this, generalized covariance first requires running of a standard covariance analysis with the filter gains at each measurement being written on the GAIN file. The GAIN file should be created in the course of any standard covariance analysis

if it is anticipated that a generalized covariance will be run later to evaluate suspected mismodeling.

In execution, generalized covariance operates on a set of "true" covariances, propagating them by using the STM file and updating them at a measurement with the assumed filter gain from the GAIN file. The "true" covariances may have different a-priori levels on some parameters and may even include parameters not appearing in the original error analysis. The resulting output may then be compared to the original results to determine the sensitivity of the OD process to the mismodeling.

Note that generalized convariance handles, in effect, two types of mismodeling: differences in the level of process uncertainty and mismodeling of the process itself. Obviously, a more rigorous analysis would apply the trajectory simulation mode, SIMSEP. However, running SIMSEP would be very costly to produce the studies that generalized covariance can perform in one short run. This assumes of course that linearity is valid which is the key assumption in GODSEP. By using generalized covariance in GODSEP, SIMSEP can be used primarily for testing linearity assumptions and not mismodeling.

4.2.1 <u>STM File Generation</u>

A basic requirement for the standard covariance analysis is a reference trajectory with associated transition matrix information. The trajectory data is first created by GODSEP and stored on a disc file (STM). The STM file can then be used and reused for any number of linear error analyses related to the reference mission.

In addition to the standard trajectory variables (Section 4.0), the $TRAJ namelist requires

- o ISTMF = 1
- o MØDE = 2
- o IAUGDC to designate which dynamic parameters are augmented to the basic spacecraft state of position and velocity
- o NEP to designate the ephemeris body if IAUGDC has activated any ephemeris body elements.

Since the STM file is intended for many applications, it is recommended that IAUGDC activate all parameters that the analyst thinks might be needed in subsequent error analyses.

The next namelist, $GØDSEP, is required to establish the grid of trajectory points at which spacecraft state and mass, thrust acceleration and other trajectory data are computed, and between which transition matrices for the augmented state are computed. The grid of time points need not correspond either one to one or to an exact time of events of a following error analysis but should be set up to cover approximately the expected events. For example, a greater intensity of time points should be inserted where Earth-based tracking arcs are anticipated whereas only a few points should be placed between tracking arcs. It is very important that the time grid on the STM file cover the maximum conceivable event schedule to avoid regeneration of an STM file.

Time points can be established in many ways. The simplest

method is to set NSCHED equal to the number of scheduling cards and then follow the $GØDSEP namelist (which would contain only NSCHED) with scheduling cards corresponding to a desired trajectory grid. Either arbitrary measurements or propagation events can be used.

An alternate scheme is to use an anticipated error analysis event schedule. That is, specify appropriate eigenvector events (NEIGEN and TEIGEN), prediction events (NPRED, TPRED and TPRED2), guidance events (NGUID, TGUID, TCUTØF and TDELAY) and NSCHED. Then follow with scheduling cards corresponding to a desired measurement schedule. Of course, the composite event schedule should be set up to cover all possible future analyses.

Whatever the method of establishing time points for the STM file, a number of additional time points will be inserted automatically. These correspond to thrust policy changes, that is, thrust reorientation and thrust/coast switching, and to changes in the number of operating thrusters.

4.2.2 Standard Covariance Analysis

Once an STM file is generated, the standard covariance analysis can be run either as a stacked case or as a separate run. The only variables required in $TRAJ are ISTMF = 2 and MØDE = 2. Inputs to $GØDSEP are much more involved and depend upon the particular analysis in mind.

The easiest GODSEP application is propagating a covariance from one time point to another. This may be desired, for example, to look at effects of thrust or other dynamic uncertainties on the

growth of trajectory errors. In this case $GØDSEP requires:

- o TCURR = input epoch of the a-priori covariance;
- o TFINAL = GODSEP termination time; this is required only if it is different from the final time on the STM file;
- o P is the a-priori covariance (in standard deviations) and associated dynamic and/or measurement covariances: CXS, CXU, CXV, PS, CSU, CSV, PU, CUV, PV. Note that the augmented parameters for a simple covariance propagation may be input as either solve-for or consider parameters;
- o IAUG denotes the augmented parameters which correspond to the input covariances and IEPHEM to the form of ephemeris uncertainty input (if any);
- o NEIGEN the number of time points at which the covariance is printed and TEIGEN is the array of time points; the exact times will correspond to whatever is available on the STM file, near the desired times, within the forward and backward time tolerances, TØLFØR and TØLBAK, respectively; the user shall keep in mind that thrust control events (switching of thrust policy or number of operating thrusters) are automatically printed at the exact times of occurrence;

- EPTAU and EPSIG are required if thrust noise is present, otherwise DYNØIS = .FALSE. must be set;
- JØBLAB is used for a job heading to describe this run.

No other input needs to be included in $GØDSEP, nor are scheduling or any other cards required.

The most common GODSEP usage is the evaluation of a navigation strategy and a set of error sources for the reference mission. This includes tracking, orbit determination (OD), guidance and, possibly, prediction, propagation and eigenvector events for additional data display. In this case, $GØDSEP requires all of the inputs needed for the simple covariance propagation plus

- CØNRD = .TRUE., and PG, CXSG, ..., PVG, for the a-priori control covariance if it is different from the input knowledge covariance, and TG, XG, GMASS to define the trajectory epoch;
- Guidance event parameters: NGUID, TGUID, TCUTØF, TDELAY, CØNWT, IGPØL, IGREAD to denote

characteristics of the thrust update process; if IGPØL is zero for any guidance event (that is, an artifical guidance event whose sole function is to print the control covariance, analgous to an eigenvector event), then the corresponding event values in TCUTØF, TDELAY, CØNWT, and IGREAL are ignored;

- Other non-measurement events: NEIGEN and TEIGEN for eigenvector; NPRED, TPRED and TPRED2 for prediction;
- IGAIN for the type of OD filter;
- SIGMES, SIGRS, SIGLØN, SIGZ, CØRLØN for tracking measurement noise standard deviations;
- PUNCHE to denote at which event types punched card output is obtained (covariance and state);
- NSCHED

There are of course many optional parameters which may be input depending upon the particular GODSEP application. For example, if the number of 2-way doppler measurements per day is different than 12, then DØPCNT should be changed, or, if the error analysis event schedule must be meshed with a fairly different STM grid, then the tolerances TØLFØR and TØLBAK might be altered.

With regard to schedule tolerances, the user should keep in mind the process of which events are chosen to be executed at which

STM time points. For example, in Figure 4-2, Event E_1 will be performed at the STM time point STM(I). Event E_2 will not be processed

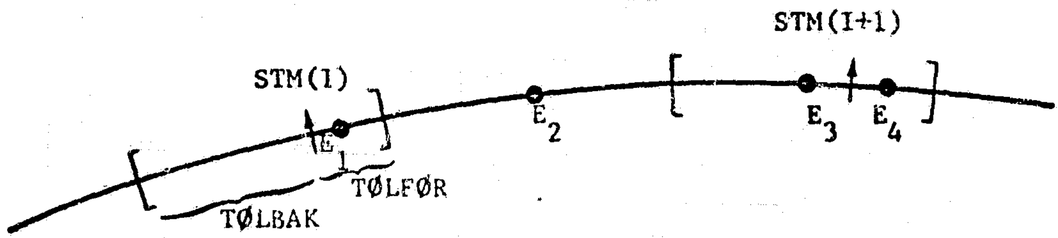

Figure 4-2. Event and STM Meshing

at all; if SCHFTL = .TRUE., then the run will be terminated immediately. Events E_3 and E_4 will both occur at STM(I+1). In Figure 4-3, where TØLBAK is so large that it overlaps a previous STM point, E_1 is still executed at STM(I) because an earlier STM point and its tolerances take precedence over subsequent STM points. Events E_2, E_3 and E_4 are all executed at STM(I+1). Thus, it is very important that some foresight be applied to creation of the STM file and some consideration be applied to the use of the STM file in event scheduling of a covariance analysis.

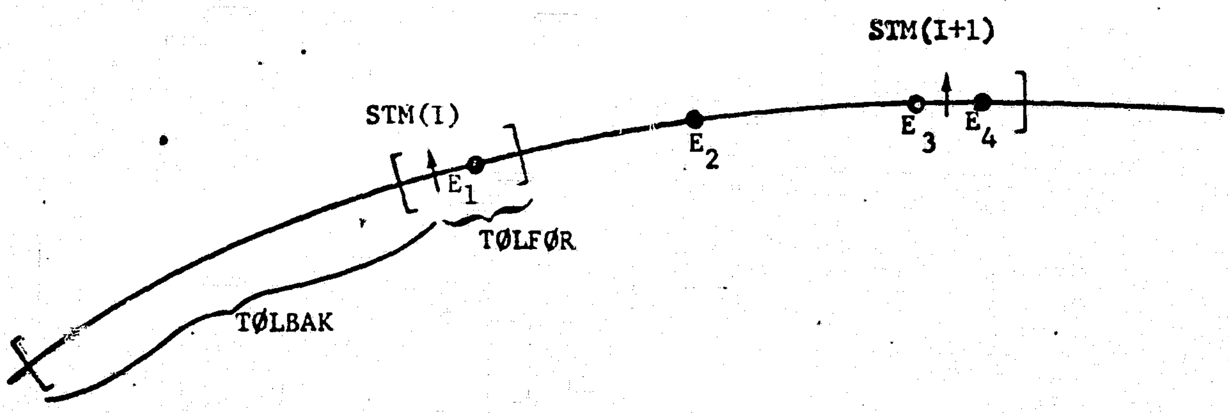

Figure 4-3. Event and STM Meshing

A number of print and input/output options also exist in $GØDSEP. One of the more important output controls is GAINCR which determines whether or not a GAIN file is to be created for a subsequent generalized covariance analysis (Section 4.2.4). Another option is the punch flag, PUNCHE, which produces punched cards of state and covariance for selected event types. This option is quite useful in subsequent error analyses to eliminate unnecessary repetition of mission segments, especially tracking arcs.

Following the $GØDSEP namelist are fixed field schedule cards which determine the type, density and span of measurements used for navigation and the spacing of propagation events. Propagation events are used primarily to condition the process noise terms, in particular, to break up long propagation intervals, for example those greater than 50 days, wherein there are no other events and in which the effective process noise model breaks down.

An option which can be used to facilitate parametric operation of GODSEP is storing the $GØDSEP namelist on the GAIN file (GAINCR = .TRUE.) even if no subsequent generalized covariance analysis is intended. In any following error analysis run, setting ISTMF = 3 in $TRAJ will cause the $GØDSEP namelist to be read off the GAIN file and the user need only input those parameters in $GØDSEP which are different from the run that created the GAIN file. The user will still, however, be required to input NSCHED and follow the $GØDSEP namelist with the appropriate measurement and propagation event scheduling cards.

C-3

After the scheduling cards there exists the possibility of one more set of cards, the namelist $GEVENT. If guidance events are requested and if any of the entries in IGREAD (in $GØDSEP) are non-zero, then the $GEVENT namelist must be input immediately after the scheduling cards. If IGREAD = 2, $GEVENT allows input of VMAT, the variation matrix of target parameters with respect to guidance start state, SMAT, the sensitivity matrix of target with respect to guidance thrust controls and BURNP, guidance burn parameters. If IGREAD = 1 or 2, $GEVENT also allows updating of values in CØNWT, NCØN, TARWT and UMAX. One $GEVENT namelist is required for each non-zero entry in IGREAD up to the number of guidance events (NGUID). Using $GEVENT increases the speed of a GODSEP run by eliminating guidance related computations already performed by earlier runs. A standard output at all guidance events are punched cards for VMAT, SMAT and BURNP whenever these matrices are computed and not already input.

It is apparent that GODSEP input (Figure 4-4) is complicated because of the requirement for extensive analysis capability.

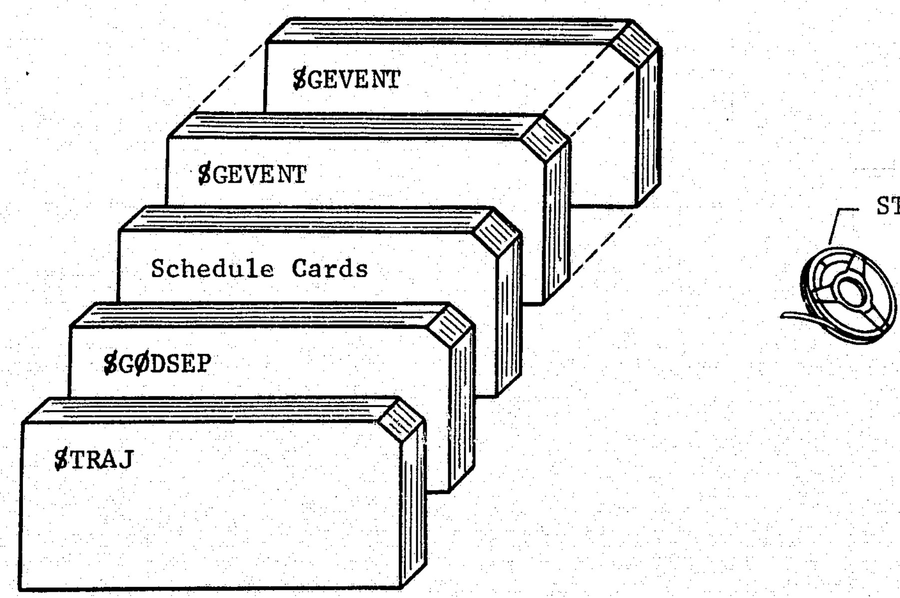

Figure 4-4. Standard Covariance Analysis Input

There is no substitute for experience in terms of what input/output options are chosen and what sequence of GODSEP runs should be made for a specific mission or problem.

4.2.3 Combined STM File Generation and Error Analysis

In general, it is not recommended that GODSEP cases be stacked in a single run because of the amount of output which the user should look at before submitting the next case. There is one recognized exception -- combining the STM file generation with a standard covariance analysis. However, even this stacked case is not without peril because of the danger of miscreating the STM file with subsequent operation by an unsuspecting covariance analysis. The combined STM generation and analysis run may be used for two reasons: (1) the covariance analysis is a simple check case to verify the adequacy of the STM file, or (2) the reference mission is relatively unique and no further analysis is anticipated.

The inputs to MAPSEP are straightforward (Figure 4-5) and

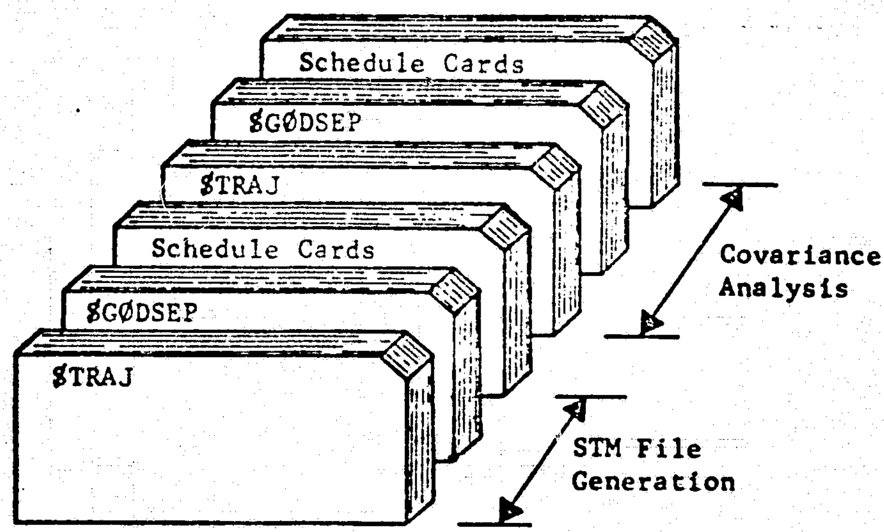

Figure 4-5. Combined STM Generation and Error Analysis Input

follow the detailed descriptions contained in Sections 4.2.1 and 4.2.2 for generation of the STM file and covariance analysis, respectively. Since GODSEP does not retain event information from one run to the next, the event and scheduling cards used to generate the STM file must be repeated for the error analysis (assuming the STM file is to be applied only for that error analysis).

4.2.4 Generalized Covariance

A standard covariance analysis (SCOV) assumes the OD filter knows percisely the form, behavior and initial level of any process uncertainties, and can estimate and/or consider their appropriate effects. Generalized covariance (GCOV) is used to examine differences between the assumed and real-world uncertainties as they interact with the OD process. Thus, an explicit requirement for exercising the GCOV option is a previous SCOV run which has written its filter gains on a GAIN file (GAINCR = .TRUE. in $GØDSEP). The GCOV run(s) can be stacked behind the SCOV, although this is generally not recommended.

Exercising GCOV requires two tapes or files, STM and GAIN. The $TRAJ namelist requires only MØDE = 2 and ISTMF = 3. The $GØDSEP namelist also requires only a few inputs because the measurement, propagation, and print schedule, a-priori covariance, noise levels, etc. are all obtained from the GAIN file. Thus, $GØDSEP input is

- GENCØV = .TRUE. and GAINCR = .FALSE.;
- IAUG to activate ignore parameters, that is, those parameters known to the real-world

(GCOV) but not by the assumed world (SCOV); note that only those parameters not already activated as solve-for or consider in the SCOV are available to be used as ignore parameters;

- CXW, CSW, CUW, CVW, PW (covariance terms) for the ignore parameters;
- Any parameters to be mismodeled, for example, covariance P, CXS, ..., PV, measurement noise SIGMES, thrust noise EPTAU and EPSIG, etc.;
- Changes in events, although this is not recommended because it may alter the covariances even without mismodeling.

If the user is confident of his input, then several cases of GCOV can be stacked (by repeating the $TRAJ and $GØDSEP input described above). Such a run might include, for example, comparison of different thrust noise levels and correlation times from those assumed by the OD filter. The sensitivity to mismodeling of thrust errors can be a very important criteria in the choice of an OD filter for low thrust missions.

4.2.5 PDOT

One of the key assumptions in a standard covariance analysis is the effective thrust noise model. A means of evaluating this model, as well as other dynamic modeling assumptions is the explicit

integration of the covariance matrix differential equations (PDOT). This is in contrast to the transition matrix methods used in the standard covariance analysis.

Since no transition matrices are required, the STM file is not needed except in the possible case where a default $TRAJ namelist is desired which contains reference trajectory parameters. In this case, MØDE = 2 and ISTMF = 2 are the only inputs required in $TRAJ. Otherwise, the normal $TRAJ inputs are required: TLNCH, ..., NB, along with MØDE = 2 and ISTMF = 0.

The $GØDSEP namelist and scheduling cards are identical to that used in the standard covariance run (Section 4.2.2) except for PDØT = .TRUE. Most of the options are also available, for example, generalized covariance.

There are a number of restrictions on PDOT capability because of its function as a support option intended to check on covariance propagation modeling. In particular, no prediction or guidance events can be performed. Furthermore, if the input covariance epoch, TCURR, is not equal to the trajectory epoch, TSTART (in $TRAJ), then STATE and SCMASS in $TRAJ must be altered and correspond to TCURR.

4.3 Trajectory Simulation - SIMSEP

The two main purposes of trajectory simulation are to examine (1) deterministic trajectories, especially the effects of dynamic nonlinearities, and (2) the impact of process mismodeling on trajectory errors. Each trajectory is simulated in an operational environment with a parallel set of "real world" and "assumed world" conditions. The real world conditions are randomly selected from a set of uncertainties associated with the dynamic, environmental, and systems models. The assumed world conditions represent a best estimate of what the real world is like. It is obtained by direct (but corrupted) and indirect observations of the real world processes. The trajectory or mission is carried through a set of trajectory related events, e.g., orbit determination and guidance, until a stopping condition is reached, usually target encounter.

Once a mission has been completed, the trajectory is characterized by fuel expenditure, terminal error, magnitude of thrust control updates, etc. In line with the main objectives, a comparison can then be made between real and estimated world terminal conditions. Furthermore, it will also be possible to make a comparison between real (and estimated) terminal conditions computed in SIMSEP and results computed in an equivalent linear error analysis run. Based upon these comparisons many actions may be taken, the most obvious being an update of assumed world processes and models to reflect the real world more accurately.

SIMSEP has been designed to run a sequence of trajectory simulations in order to generate statistics on the terminal conditions.

Clearly, the confidence attached to these statistics is largely dependent on the number of samples taken. As a consequence, this Monte Carlo approach is, generally, very expensive in terms of computer processing time. This often restricts SIMSEP operation to a support role or to analysis of specific processes, e.g., terminal guidance algorithms or thrust noise effects.

Because SIMSEP can have a complicated input, and is expensive to run, it is recommended that a zero-error case be made first to prevent undue expense as a result of input mistakes. This involves running a single cycle of the reference mission, including all guidance events and related inputs, but with zero-values input for dynamic errors or knowledge uncertainties. The results from one mission cycle with no errors should compare favorably with the targeted reference trajectory obtained from TØPSEP, except for small differences due to numerical integration noise. After a successful zero-error case, SIMSEP can be executed to examine any desired problem.

4.3.1 <u>Single Cycle - No Error</u>

The zero-error case is a means of verifying the basic mission input and is one of the easiest SIMSEP runs to make (Figure 4-6).

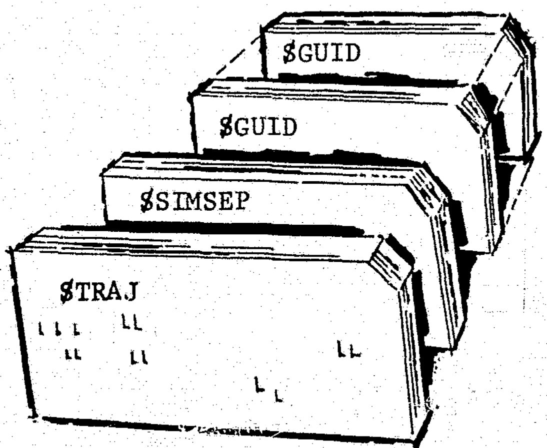

Figure 4-6. SIMSEP Mode Input

After the standard ȻTRAJ namelist containing TLNCH, ..., NB, and MØDE = 3, the input to ȻSIMSEP is NGUID for the number of maneuvers or guidance events and INREF = 0, forcing SIMSEP to compute reference trajectory conditions at each event and at the final time. For each guidance event, there must be a corresponding ȻGUID namelist containing

- o KTER to determine whether or not target conditions are to be computed after this guidance event in order to evaluate its success;
- o TGUID for the maneuver epoch;
- o ITARGT and IGUID for the guidance philosophy;
- o H array to define the active low thrust control parameters for this guidance event; note that controls can be either an impulsive delta-velocity or low thrust parameters and if they are impulsive no entries are necessary in H;
- o NTP for the target body code;
- o TTARG for the target time;

- o UWATE for control parameter weights;
- o TARTØL for allowable tolerances on the target errors; and
- o NMAX for the maximum allowable number of iterations if nonlinear guidance is specified.

The zero-error case should result in extremely small guidance corrections and target errors. Besides confirming the mission and guidance input, a zero error case will generate punched card output (independent of IPUNCH) which will greatly facilitate subsequent SIMSEP runs. Assuming INREF = 0, the punched cards will include at each guidance event, the reference state, mass, target variables and either a sensitivity matrix of target parameters w.r.t. control parameters (for the nonlinear guidance case) or a guidance matrix of control corrections w.r.t. state errors at the guidance time (for linear guidance). The reference state and mass at the trajectory end (TEND) time will also be punched.

4.3.2 <u>Single Cycle - Forced Monte Carlo</u>

A very useful method of evaluating either specific errors or worst case missions is a "forced" Monte Carlo run. With the random number seed, IRAN, set to zero, all error sources are set at their one sigma levels. Thus, discrete known levels of errors can be studied, instead of randomly sampled. Of course, if all the error levels are one-sigma, the mission itself may represent a very improbable case, possibly as high as 100 σ.

Input for a forced Monte Carlo run is the same as for the

previous zero-error case with the obvious exception of non-zero errors. The ØTRAJ namelist is the same, and the ØSIMSEP namelist contains

- IRAN = 0;
- Ephemeris and gravitational errors: EPHERR, GMERR; NEP2 to identify the ephemeris body(s); TEPH for the epoch(s) at which ephemeris uncertainties are evaluated;
- Spacecraft and thrust related errors: SCERR, TCERR, TVERR;
- ΔV execution errors: EXVERR, if there are impulsive maneuvers; the chemical propulsion specific impulse SPFIMP;
- The control covariance, PG, representing the initial position and velocity uncertainties; a forced Monte Carlo state error consists of a vector containing the square root of each eigenvalue rotated back into state space;
- AØK, the upper bound of acceptable quadratic target error for non-linear guidance events (total convergence occurs when the quadratic target error is less than unity);
- INREF = 0, or if reference conditions are available, then INREF = 1, and the reference state and mass at the final time (XEND and MEND, respectively) must be input;

o NGUID for the number of maneuvers.

Each $GUID namelist must contain

o KTER, TGUID, ..., NMAX, the guidance characteristics as in the zero error case;

o If INREF = 1 in $SIMSEP, then the reference state (XGREF and mass MGREF) at the maneuver epoch, target conditions (TARGET, XTREF, MTREF) and either the sensitivity matrix for nonlinear guidance or the guidance matrix for linear guidance (S) must all be input;

o KDIMEN to denote the augmented parameters to the spacecraft state which have been estimated for this maneuver; NEP identifies the ephemeris body if the augmented state includes ephemeris or gravitational parameters;

o P, PS, CXS are estimation uncertainties corresponding to the spacecraft state, augmented parameters and correlations, respectively.

The forced Monte Carlo option is often used in parametric fashion to study specified levels of a particular error source, for example, thrust noise. Stacked cases can be used to perform the parametric study by repeating the namelist sequence $TRAJ, $SIMSEP and the appropriate number of $GUID's. An alternate, and more efficient, method is to set MØDE = -3 in the first case $TRAJ namelist and make use of the fact that the initial $SIMSEP and $GUID namelists are saved on disc. After the first case, the $SIMSEP and $GUID namelists are repeated for each subsequent case. If this

operational procedure is used, those variables that are different from the first case need to be redefined during input after the variables read during the previous analysis are set to zero. In addition, the user must be careful to read zero-length namelists, i.e. $SIMSEP or $GUID card followed by a $END card, for all namelists nominally requested even if the original is unchanged.

4.3.3 Monte Carlo

The most often used application of SIMSEP is in the Monte Carlo mode where all mission uncertainties are sampled and the trajectory is simulated accordingly. By looking at a number of typical missions, each with varying degrees of expected errors, an idea of the trajectory errors and required control corrections can be obtained. Statistical analysis of key parameters, such as final target error and mass, total required thrust control correction, etc. should evaluate or define realistic system constraints and probability of mission success. Obviously, a large number of missions, on the order of hundreds, are needed to have reliable statistical data, but even a few sample missions will reveal the scope of trajectory non-linearities and mis-modeling effects.

Input to a full Monte Carlo simulation is basically the same as that for the forced Monte Carlo. The namelists $TRAJ, $SIMSEP, and $GUID are all needed with parameters as specified in the previous section. Additional variables to be considered in $SIMSEP are

- IØUT to specify which sample missions are to be printed in detail; if only a few missions are

generated then all of them should be printed;

- IPUNCH = 1 to provide punched cards of all the cumulative statistics at the end of the run; this will allow a subsequent run to continue the statistical analysis rather than starting anew;
- IRAN is the random number seed, typically set to unity for the first Monte Carlo run;
- NCYCLE for the number of missions to be simulated;
- CPMAX is an optional parameter for maximum computer processing time; if the actual processing time approaches CPMAX and it is estimated that the desired number of missions (NCYCLE) cannot be completed, then the current mission is completed and final output is generated. This includes punched cards for restarting another run.

The cost of simulating one sample mission with a number of guidance events can be quite high, especially if nonlinear guidance is used. Therefore, it is recommended that considerable planning be made before a full Monte Carlo study is run. Some of the possible short cuts are increasing the trajectory integration step size (STEP in $TRAJ), using linear guidance wherever possible, minimizing the maximum number of iterations (NMAX in $GUID) for nonlinear guidance, and eliminating unnecessary computations (for example, KTER = 0 in $GUID). Another possibility is simulating only key mission segments, in particular the terminal approach phase, and studying other segments with a few simulations and/or with the forced Monte Carlo option.

4.3.4 Monte Carlo Continuation

It is often wise to divide a Monte Carlo analysis into smaller sample sizes than one large run. This serves two purposes: (1) the early detection of input errors before sizable computer time is spent, and (2) examination of missions as they are generated. The latter reason could conceivably result in a change in guidance strategy which would cause the Monte Carlo study to begin again.

A prerequisite to the Monte Carlo continuation are punched cards containing statistical results of all previous runs (IPUNCH = 1 in $SIMSEP). The input to a Monte Carlo continuation is the same as in the previous section except for inclusion of the cumulative statistics. In $SIMSEP these include the total thrust control correction covariance (only of the active controls used in guidance events) ATHCOV, total ΔV variance, ADVT, state covariance at the final time ENDCOV, final spacecraft mass variance AMASS, and the number of Monte Carlo cycles used to generate these statistics, MC. In each $GUID namelist the parameters to be included are: state control covariance CCØVG, ΔV covariance DVMCØV, ΔV magnitude variance DVMAG, spacecraft mass variance GMSCØV, thrust control correction matrix CNTCØV, state error covariance at the target time CCØVT, spacecraft mass variance at the target time TMSCØV, target error covariance TARCØV. CCØVT, TMSCØV, and TARCØV are computed only if KTER = 1. The number of maneuvers used in computing these statistics is specified by the variable MSAMP. All of the matrices noted above contain not only variances and covariances but also the cumulative mean values.

Note that the number of samples used to generate each maneuver may be different from each other and from the number of samples used to generate the total mission statistics. This results from maneuvers which do not converge or fail to achieve the weak convergence criteria (AØK) and are not included in the cumulative statistics. A divergent maneuver is taken to be "catastrophic" and the current Monte Carlo mission cycle is terminated with no further guidance events or statistics being computed until the next cycle.

Additional input for the Monte Carlo continuation run is the random number seed (IRAN in $SIMSEP) which is typically set to the number of the next cumulative Monte Carlo cycle to be run. No changes in the reference trajectory, guidance strategy or error sources should be made between runs, otherwise the statistical results will be invalidated.

4.4 Case Stacking and Mixed Mode Operation

Case stacking is generally not recommended within modes and definitely not recommended for mixed mode operation. There is too much room for error, even for the experienced user, to assume the input and operation of one case will successfully provide the required data for the next case. There are a few exceptions which might warrent case stacking, and some of these conditions have been discussed in previous sections.

The MØDE flag in namelist $TRAJ controls not only the mode (TOPSEP, GODSEP or SIMSEP), but also the point to which program logic will cycle back. A positive MØDE will return to MAPSEP main and will expect a $TRAJ namelist for the next case. A negative MØDE will return to the mode main and expect a mode namelist. Note that once recycling is done within the mode, logic will never return to MAPSEP main, therefore, (1) any subsequent cases must apply only to that mode and (2) no changes to the reference mission are allowed.

Some of the possible conditions under which case stacking might be performed are:

Mode	MØDE Flag	Function	Conditions
TOPSEP	+1	Trajectory Propagation	Generating time histories for different missions.
TOPSEP	+1 or -1	Initial Guess	Generating more than one initial guess for subsequent targeting by applying different sets of initial conditions, thrust parameters, and/or mission constraints for each case.

Mode	MØDE Flag	Function	Conditions
TOPSEP	-1	Grid Generation	Extending the scope of the trajectory grid.
TOPSEP	-1	Targeting	Examining various targeting strategies for a given mission.
GODSEP	+2	STM Generation	Generating a STM file with verification by a simple error analysis check case.
GODSEP	+2	Covariance Analysis	Generating a STM file for a unique mission with a subsequent error analysis.
GODSEP	+2	Covariance Analysis	Analyzing different navigation strategies and/or error sources for the same mission.
GODSEP	+2	Generalized Covariance	Performing a standard error analysis to generate a GAIN file and using generalized covariance to evaluate suspected mismodeling effects.
GODSEP	+2	Generalized Covariance	Analyzing different mismodeling assumptions with generalized covariance runs.
GODSEP	+2	PDOT	Performing parametric variations of dynamic error sources and evaluating their covariance propagation effects with the PDOT option.
SIMSEP	+3	Missions	Simulating several different missions for comparison.
SIMSEP	+3	Errors	Examining different sets of error sources on the same mission (forced Monte Carlo).
SIMSEP	-3	Guidance	Examining different guidance strategies for a given mission.

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